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# Observations on the biology and ecology of the little house fly, Fannia canicularis (L.).

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TABLE OF CONTENTS

# INTRODUCTION

The annoyance produced by flies in abundance is a serious problem. Recently, complaints by residents and poultrymen of Massachusetts of heavy fly populations have increased, especially in the early spring.

A preliminary survey revealed that this situation was common and had resulted in action by local public health officials in some areas. The problem has been aggravated by rapidly expanding residential sections encroaching around established poultry farms.

Although the role of the little house fly in the transmission of diseases has not been determined, it is acknowledged that flies are well adapted by structure and habit for the mechanical transfer of microorganisms from feces and other filth to food. There are several records incriminating this species as the cause of intestinal and urinary myiasis in humans.

A search of the literature disclosed that little effort has been expended concerning biological and ecological studies of this species. In 1956 Dr. Harvey L. Sweetman and Dr. Frank R. Shaw applied to the U. S. Public

Health Service for financial assistance to support investigations concerning this fly. These efforts resulted in the establishment of Public Health Grant E-1027-R.

The intention of this study was to accumulate and evaluate existing information and contribute additional knowledge concerning the biology, ecology and importance of this fly. This study was confined largely to investigations in the laboratory and on poultry farms in Massachusetts.

# REVIEW OF LITERATURE

## SYSTEMATICS

Taxonomic position: There has been disagreement among dipterologists regarding the proper super-generic status of *Fannia canicularis*. Three schools of thought are expressed in the literature (Table 1). They are:

1) Those which favor a distinction between the family Anthomyiidae and Muscidae.
2) Those which feel that the Anthomyiidae cannot be separated from the Muscidae and should be included therein.
3) Those which feel that the species within the genus *Fannia* are distinct from either the Anthomyiidae or the Muscidae to the extent that a new family (Fanniidae), intermediate in position, is justifiable.

TABLE 1

VARIED OPINIONS REGARDING THE SUPER-GENERIC STATUS OF
_F_. _canicularis_ (L.)

| Reference | Family | Sub-family |
|---|---|---|
| Comstock, 1950 | Anthomyiidae | Fanniinae |
| Essig, 1942 | Anthomyiidae | ---------- |
| Brues _et_ _al_., 1954 | Anthomyiidae | Fanniinae |
| Borror & DeLong, 1954 | Anthomyiidae | ---------- |
| Curran, 1934 | Muscidae | ---------- |
| Lindner * | Muscidae | ---------- |
| Colyer & Hammond, 1951 | Muscidae | Phaoniinae |
| Roback, 1951 | Fanniidae | ---------- |
| Ross, 1956 | Fanniidae | ---------- |

* Sabrosky, (1939)

In consideration of the controversial super-generic status of this genus, the author presents Comstock's (1950) and Brues' _et_ _al_. (1954) classification for the following reasons:

1) Both texts are widely used American references and present a traditional view of the names and broader scope of many of the families.

2) The family name of Anthomyiidae has been in more or less continuous use for a long time and thus has become widely established and continues to appear in the literature.

This classification is presented as follows:

<u>Order</u>--------------------Diptera

<u>Sub</u>-<u>order</u>----------------Cyclorrhapha

<u>Series</u>-------------------Schizophora

<u>Section</u>------------------Myodaria

<u>Sub</u>-<u>section</u>--------------Calyptratae

<u>Super</u>-<u>family</u>-------------Muscoidea

<u>Family</u>-------------------Anthomyiidae

<u>Sub</u>-<u>family</u>---------------Fanniinae

<u>Genus</u>--------------------*Fannia*

<u>Species</u>------------------*canicularis*

Chillcott (1958), a Canadian systematist who recently completed a Nearctic revision of the genus, comments that although his own research strongly substantiates Roback's grouping, there still remains insufficient evidence to comply with his proposal. Chillcott prefers to retain the the sub-family rank Fanniinae until a world revision has been completed.

<u>Synonomy</u>: The catalogs of Aldrich (1905) and Neave (1939) proved to be valuable references in determining the systematic derivation of the binomial *Fannia canicularis*. However, confusion arose concerning the first use of generic names and the first use of these generic names in actual combination with the specific name. Correspondence

with J. G. Chillcott aided in clarifying points of importance.

Linnaeus, in 1746, was the first to describe this species as Musca canicularis in Part II of Fauna Suecia. However, since it has been agreed by systematists to recognize 1758 as the beginning of approved nomenclature, this first appearance of M. canicularis is disregarded; and thus its appearance in the 12 th edition of Systema Naturae, 1761, is regarded as the first official use of a binomial for this species.

In 1826, Meigen subdivided the huge genus Musca, and canicularis was subsequently placed in his newly erected genus, Anthomyia. Shortly thereafter, in 1830, Robineau-Desvoidy proposed the genus Fannia, and in 1834 Bouche erected the genus Homalomyia. However, neither of these latter authorities included canicularis within his newly erected genus.

The first examples of these new generic names in combination with the specific name was Homalomyia canicularis by Westwood in 1840 and by Stein in 1907. Stein was the first to give the older name priority by using Fannia canicularis as his designation for this species (Chillcott, 1958). The genus name Homalomyia was also spelled as Homolomyia and both spellings are found in the literature.

Aldrich (1905) lists only a few synonoms of this species. However, through correspondence with Chillcott (1958), a more extensive list was compiled. The list includes:

_Musca canicularis_ Linnaeus, 1761
_Musca minor domestica_ DeGeer, 1776
_Anthomyia canicularis_ Meigen, 1826
_Philinta canicularis_ Robineau-Desvoidy, 1830
_Philinta pallipes_ Robineau-Desvoidy, 1830
_Anthomyza canicularis_ Zetterstedt, 1838
_Homalomyia canicularis_ Westwood, 1840
_Anthomyia fulvomaculata_ von Roser, 1840
_Anthomyia chilensis_ Macquart, 1843
_Anthomyia constantina_ Macquart, 1843
_Aricia canicularis_ Zetterstedt, 1845
_Anthomyia isura_ Walker, 1849
_Anthomyia introducta_ Walker, 1856
_Anthomyia tuberosa_ Curtis, 1860
_Homalomyia prunivora_ Walsh, 1869
_Anthomyia muscoides_ Walker, 1871
_Homalomyia mexicana_ Bigot, 1885
_Homalomyia fucivorax_ Keiffer, 1889
_Homalomyia fraxinea_ Hutton, 1901
_Fannia canicularis_ Stein, 1907

<u>Common names</u>: Several common names have been used by authors in mentioning *F. canicularis*. They are:

"Dog day fly"

"Flat flies"

"Puppy flat flies"

"Small house fly"

"Lesser house fly"

"Little house fly"

Until recently, the common name that appeared most consistently in the literature was the "lesser house fly". Muesebeck (1946), reporting for the Entomological Society of America, listed the "little house fly" as the accepted common name for this species.

<u>Semantic derivation of *Fannia canicularis*</u>: To determine the intended meaning of descriptive Latin or Greek names given insect species by their author often provides an interesting journey into semantics. According to Webster's dictionary (G. C. Merriam Co., 1952), the meaning of the words are as follows:

*Homalomyia* (Greek), homalos; meaning flat and myia, meaning fly.

*Fannia* (Greek), phanos; meaning conspicuous.

*canicularis* (Latin), canicular; pertaining to canicular or dog days occurring in July and August.

## RECOGNITION CHARACTERS

The family Anthomyiidae: The hyopleural and the pteropleural hairs or bristles absent; abdomen usually bristly; 4th vein curving backwards (if curving forward, the arista is not feathered to the tip): arista sometimes bare (Brues *et al*., 1954).

The sub-family Fanniinae: Anal veins very short, stopping abruptly, not traceable to the wing margin. The 7th vein (axillary or $A_2$) more or less distinctly curved forward, around the apex of the 1st anal vein; female with wholly convex front, the broad orbits bearing two fronto-orbital bristles on upper half, directed outward over eyes, or the upper eyes, or the upper one pointing slightly backwards; middle tibia of male more or less with heavy pubescence and often swollen on the inner side.

Lower sternopleural bristles absent, or if present, more proximal to one of the upper sternopleurals than to the other. Central group of hairs usually absent from pteropleura, but if present, the front of the male is narrower than that of the female; dilation of palpi is inconspicuous; parafacials bare below antennal base; hind tibia of male possessing a strong dorsal bristle just beyond the middle (Brues *et al*. 1954).

<u>The genus Fannia</u>: Body small and greyish pollenose in color; lighter areas often present on abdomen; proboscis short with a fleshy labellum; palpi not expanded, arista lightly pubescent or bare; frontal bristles 3-6, fronto-orbital bristles present; anterior fronto-orbital bristles usually divaricate; cruciate frontal bristles wanting; inner and outer vertical bristles present.

Usually two sternopleurals present, with a third one infrequently present; 1-2 precutellar dorsocentrals; scutellum bearing 2 lateroscutellars, 2 discoscutellars and 2 apicoscutellars; calypters relatively small, with the lower ones slightly larger than the upper.

<u>The species canicularis (L.)</u>; The adult: The characters essential for recognition of the adults of <u>F. canicularis</u>, according to Graham-Smith (1914), are:

"Length-6 mm.; span of wings 12 mm.

"Head- in the male, the eyes are reddish and close together, being separated by a width equal to one seventh the diameter of the head. In the female, they are more widely separated, the area between the eyes being one third the diameter of the head. The frontal stripe is black, but the frontal margins of the eyes and cheeks are silvery white in the male and grey in the female. The antennae are blackish grey, with non-feathered aristae. The palps are black.

"Thorax- Blackish grey, with three plainly marked longitudinal black stripes in the female. The scutellum is grey and bears long bristles.

"Wings- Clear. The end of the fourth longitudinal vein is parallel to the vein above it, not bent forward. In the resting position, the tips of the wings are closer together than in the house fly, thus increasing the narrower appearance of the insect. Squamae large and white; halteres yellow.

"Legs- Black. The femora of the middle legs bear comb-like bristles beneath.

"Abdomen- Five segments visible. Narrow and tapering, dark brown in color, and has yellow-buff patches on each side of the basal half in the male, but in the female, this yellow area is on the basal portion of the abdomen only. In the male, this yellow area is transparent when viewed against the light."

The larvae: Greene (1956) provides a valuable description of the third instar larva as follows: "pale, testaceous; broad, slightly flattened, tapering toward the head, which is small and retractile into the under part of the first segment; first segment with two, long, slender, lateral tubercles on each side; segments 4-10 each having two, long pointed tubercles on each side; last segment bearing six, long pointed tubercles; all lateral tubercles on segments 3-11 have several, sharp, black spines at their base. Along the dorsal central area of segments 2-10 is a double row of long pointed tubercles, with fine spines at their base; segments 3-10 each bearing several small, black spines at each posterior corner. Posterior spiracles raised with three lobes at the apex, lobes darker along their edges; button round. Larvae are 5-7 mm. long and 5 mm. wide."

Lewallen (1954) also provides descriptions for differentiating between three larval instars as follows:

"First instar = 1.5 mm. long, translucent white, with only the tips of the mouth hooks black.

"Second instar = 3 mm. long, translucent white, middle portion of cephalo-pharyngeal skeleton black, as are the mouth hooks.

"Third instar = 6-7 mm. long, light brownish in color, cephalo-pharyngeal skeleton entirely black."

The pupa: The pupal stage can be differentiated from the other immature stages as a quiescent larva that has ceased feeding, retracted the cephalic region, becoming somewhat shortened and thickened, with the integument hardened and dark (Lewallen, 1954).

The egg: Lewallen (1954) describes the egg as "white, elongate (approx. 2 mm. long) and encased in a sheath which is ribbed below and extends along each side of the egg as a flattened, winglike process with a reticulated area on top, between the processes."

Keys to species of Fannia: Chillcott (1958), in an unpublished manuscript, lists 97 Nearctic species of this genus, almost half of which are new species or new Nearctic records. Published keys which are available include Malloch's (1924) keys to Nearctic species, including 35 species, and Hennig's 1955 revision of the Palearctic species.

## GEOGRAPHICAL DISTRIBUTION

Chillcott (1958) reports this fly as being almost as cosmopolitan as M. domestica, apparently having followed man around the world in a similar manner. It has extended north well beyond the range of the housefly, so that in Iceland, it is the only common household fly.

James (1947) furnishes a comprehensive list concerning the geographical distribution of F. canicularis. Political units are grouped according to Wallace's zoogeographic regions rather than according to continents.

"Nearctic region: Greenland, Alaska, Nova Scotia, Quebec, Alberta, Ontario, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Pennsylvania, District of Columbia, Maryland, Virginia, North Carolina, Georgia, Florida, Alabama, Mississippi, Tennessee, Ohio, Michigan, Illinois, Minnesota, Iowa, South Dakota, Kansas, Texas, Montana, Idaho, Colorado, Utah, New Mexico, Arizona and California.

"Palearctic region: Iceland, Faeroes, Ireland, Scotland, England, Portugal, Spain, France, Netherlands, Lapland, Italy, Corsica, Malta, Sicily, Sweden, Finland, Denmark, Germany, Poland, Czechoslovakia, Austria, Hungary, Rumania, Greece, Yugoslavia, Turkey, European Russia, Azores, Canary Islands, Madeira, Morocco, Algeria, Libya, Egypt, China, Manchuria, Chosen, and Japan.

"Neotropical region: Mexico, Guatemala, Costa Rica, Colombia, Galapagos Islands, Brazil, Peru, Chile, Argentina, Patagonia, Uruguay, and Falkland Islands.

"Ethiopian region: Zanzibar, Southern Rhodesia, Transvaal, Natal and Cape of Good Hope.

"Australian region: Western Australia, New South Wales, New Zealand, New Guinea, Hawaiian Islands and Antarctic Islands."

Chillcott (1958) also reported this species from Alaska (Ladd, Fairbanks, Naknek, McKinley Park) and Canada (Cameron Bay, Great Bear Lake). The locations of these records are shown in Fig. 1.

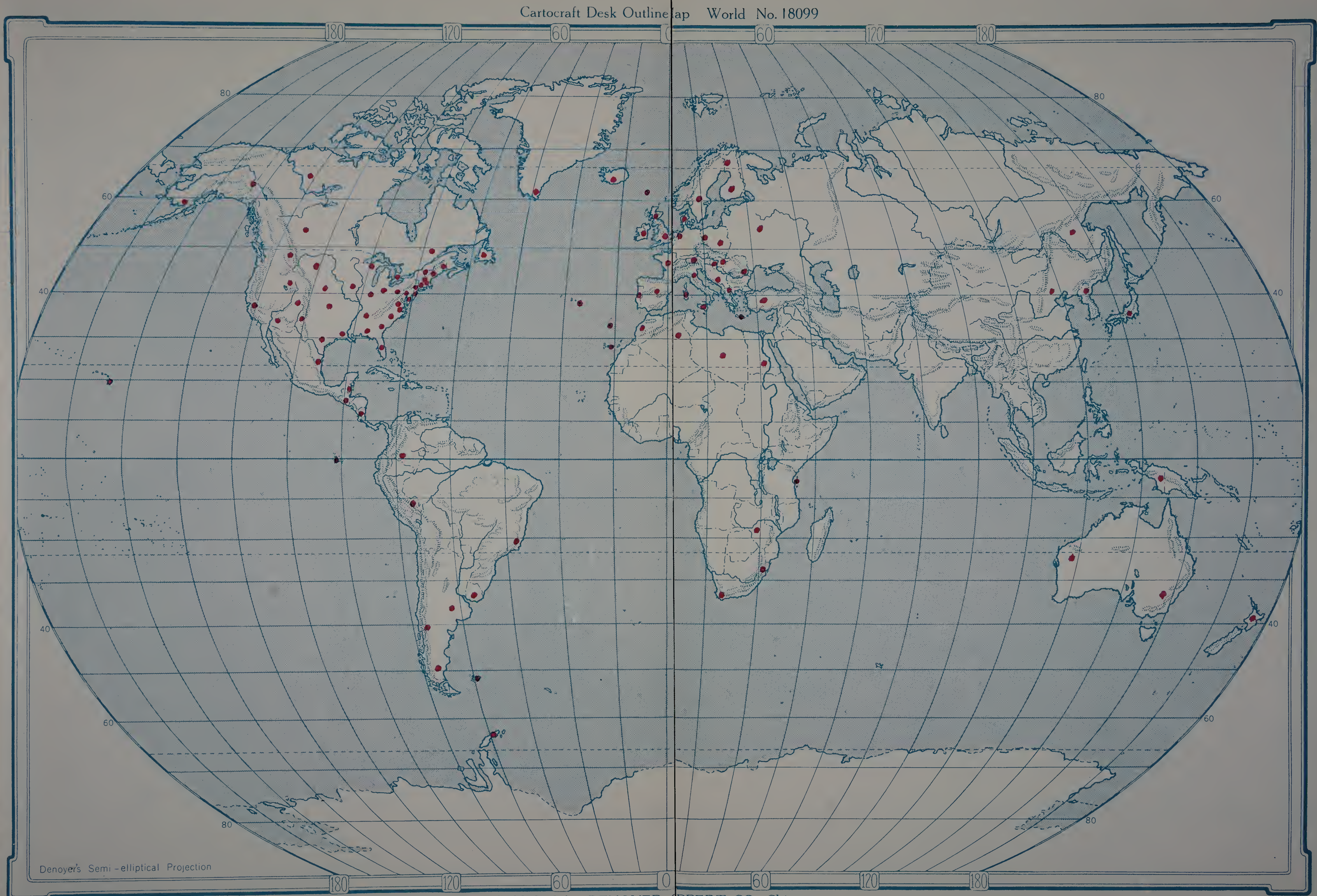



Fig. 1 -Geographical distribution of the little house fly, *Fannia canicularis* (L.)

## IMPORTANCE

Myiasis, the term proposed by Hope (1840), is now in general use to indicate the invasion of tissues or organs of man and other vertebrates solely by dipterous larvae. Patton (1921) has divided the myiasis-producing diptera into three broad categories as follows: (a) (a) _specific_; myiasis-producing diptera whose larvae are found only in living tissue, (b) _semispecific_; those flies which will occasionally lay their eggs or deposit their larvae on the diseased or soiled tissues of man and other vertebrates, (c) _accidental_; larvae which occasionally find their way into the human body, usually via the gastrointestinal tract and occasionally through the urinary passages.

A second classification used by Townsend (1942) and recommended by James (1947) is based on the part of the body affected (intestinal, aural, occular, etc.). This latter method of classification is more often used, as it better serves the need of physicians, who must make diagnoses and prescribe treatment.

Citations of human myiasis due to _F. canicularis_ have appeared occasionally through the years in the literature. In France, Chevril (1909) reported that _F. canicularis_ was frequently the cause of urinary myiasis, and Detwiler (1928) published an account of urinary myiasis in a three-year-old girl.

Pierce (1921) contends that this fly is strongly attracted to urine, resulting in infestations of the genitalia. He attributes these occurrences to the exposure of the genitals in persons who are asleep or in a drunken stupor. Neglected children might also be victimized. Oviposition about the anus of persons using privies should also be considered as a possibility.

Hewitt (1912) recorded causes of urinary myiasis, presenting detailed accounts of case histories. He also analyzed reports of twenty cases of myiasis, six of which he considered authentic, ten as probable and four as doubtful.

Onorato (1922) reported cases of urinary myiasis during the month of June in Tripolitania. Mumford (1926) reported urethral infestations by F. canicularis, considering these occurrences as unusual, since infestation from this fly was usually intestinal.

Leppanen (1950) reported a case of intestinal myiasis, this being the third such incident reported from Finland. Hewitt (1912) and Onorato (1922) also cited cases of intestinal myiasis.

Jenyns (1837) reported in detail the case of a 70 year-old Englishman who suffered from a severe intestinal myiasis, while Walsh (1870) reported a similar case of intestinal myiasis in a middle-aged, mid-western gentleman. In both of the above instances, identification of the larva as being that of the little house fly was probably erroneous, since Walsh's drawings and Jenyns' discription of "branched brachiae" more closely resemble _F. scalaris_.

Recently, Kamal and Johansen (1957), in Washington, reported _F. canicularis_ larvae in an infant's stool and urine. However, this has not been confirmed as a definite case of myiasis. Patton (1921) stated that _F. canicularis_ normally breeds outside the human body in decaying organic matter and that the flies do not instinctively deposit their eggs on certain foods or on human filth in order that their larvae might reach the intestinal or urinary tract; filth merely being their breeding grounds. Eggs and larvae of _F. canicularis_ may be swallowed on unwashed vegetables grown under unsanitary conditions.

Since _F. canicularis_ is either a semispecific or accidental myiasis agent and is strongly attracted to urinary and fecal filth, it is evident that cases of myiasis occur mostly in persons neglecting or incapable of maintaining their personal cleanliness and those consuming infested, overripe or decaying food materials. It is never an obligate parasite.

Although considerable attention has been devoted in the literature to the capabilities of this fly regarding myiasis, little attention has been focused on its role in disseminating disease-producing organisms. The author located only a single reference mentioning the fact that this fly was a carrier of the typhoid bacillus (Lochhead, 1919).

In addition to the recognition gained by this fly because of its disease-producing potentialities, its annoying presence in large numbers has also been of concern. As early as 1882, Lintner noted this species as a major household pest in New York. According to both Hewitt (1912) and West (1951), the little house fly is the most common fly found in homes, next to the house fly.

Illingworth (1923) stated that adults of the little house fly "swarmed" in a Hawaiian hotel that he visited and that the relative abundance of this fly was underestimated, since it may frequently be confused with the common house fly.

Tilden (1957) reported that complaints of *F. canicularis*, as a pest fly, were the second most important in San Jose, California, over a three year period. Other authors who have mentioned the abundant occurrence of the little house fly in homes are Graham-Smith (1914), Richardson (1917), Mellor (1919), Sasaki (1926), McDaniel (1927), and Shinoda and Ando (1935).

Wheeler (1958), reporting to the poultry industry in Massachusetts, stated that flies "present a picture of undesirable uncleanliness to the consumer and to neighbors in residential areas. The little house fly is creating problems in public relations and public health. No poultryman can afford the poor advertising provided by flies."

## BIOLOGY AND ECOLOGY

Life cycle: Only a few investigators have noted the **life** cycle of the little house fly (Table 2). None of the investigators used the same rearing medium or temperatures. It appears from these data that the optimum developmental temperature is approximately 73°F. The only worker who mentioned the number of generations per year was Roubaud (1927), who asserted that there are but four generations in France.

TABLE 2

THE LIFE CYCLE OF *F. canicularis* AS REPORTED IN THE LITERATURE

| Air Temperature, °F. and Authority | Developmental Period (Days) | | | | |
|---|---|---|---|---|---|
| | Incubation | Larval | Pupal | Preovi-position | Total |
| 63, Lodge (1918) | 1-3 | 10 | 12-24 | -- | 23-24 |
| 73, Fay (1958) | -- | -- | 14* | 6 | 20 |
| 80, Lewallen (1954) | 1.5-2 | 8-10 | 8-12 | 4-5 | 24-29 |
| --, Roubaud (1927) | -- | -- | -- | -- | 20-25 |

* Includes the two previous periods.

Seasonal distribution: Austen demonstrated that *F. canicularis* was the predominant species in houses of England during the months of May, June and July, by capturing 381 specimens of *F. canicularis* compared with only

48 specimens of M. domestica (Graham-Smith, 1914). Hewitt (1912) reported that larvae of the little house fly may be found in England from May to October.

Working in Montana, Parker (1918) trapped adults of the little house fly during July and August. This population consisted mainly of F. canicularis and F. scalaris, thus affording a record of the presence of little house fly adults in the summer months. While examining houses in England, Mellor (1919) found F. canicularis as the only fly during the fall months.

In Australia, Mackerras (1929) recorded the weekly variations of M. domestica and F. canicularis and reported that specimens of the little house fly were always scanty except in the autumn and spring. Shinoda and Ando (1935) reported that these flies were most abundant during May and July in Japan.

Lewallen (1954) recorded the occurrence of an extremely heavy infestation of F. canicularis at a Californian chicken ranch during the early spring of 1954; the little house fly constituting practically the entire fly population. At the same time, Hansens et al. (1955) reported the presence of large populations of F. canicularis on dairy farms of central New Jersey. Net sweeps in these barns revealed that F. canicularis constituted almost the entire fly population early in the season (95%, June 18), then decreased in numbers with a sudden drop at the end of July (60%, July 31), extending to the fall months (0.9%, September 3). A year later, Hansens and Scott (1955) again reported similar conditions during June and July. However, they did not indicate whether the percentage decrease was due to a reduction in the population of <u>Fannia</u> or to an increase in numbers of other flies.

Shaw and Bourne (1946) reported relatively low populations of the little house fly while determining the seasonal abundance of flies in college agricultural buildings and barns. The scarcity of this species at this time probably resulted from better manure handling practices in an effort to reduce fly populations, probable unattractiveness of the fermented corn meal baits used in their traps and a "masking" effect created by multitudes of other fly species.

<u>Overwintering stage</u>: In England, McDonnell and Eastwood (1917) screened soil in March from beneath on old manure pile covered with weeds which had been undisturbed since the previous October. At three inches below ground level, they uncovered live <u>Fannia</u> larvae. Roubaud (1927) in France and Kobayashi (1921) in Korea also found over-

wintering third instar larvae.

Overwintering pupae were observed in Japan and Korea by Kobayashi (1922, 1940b), and in England by McDonnell and Eastwood (1917).

Overwintering adults were reported by Wilhelmi (1920) in Germany and by Kobayashi (1922, 1940a) in Japan and Korea.

Diapause: Roubaud (1927) in France, stated that *F. canicularis* exhibited a "heterodynamic" diapause, with three full generations developing in the spring and summer months. The third instar larva of the fourth generation entered a "pseudo-hibernal" diapause, completely independent of low temperatures.

Kobayashi (1940b) in Japan observed that some eggs laid in October and November gave rise to adults in December, while others did not emerge until February and April of the following year. Eggs laid in December gave rise to adults in May but some of those laid in April did so in May and others in July. He attributed this variation in development to a diapause occurring in the prepupal stage of some individuals.

It seems likely that at least some of this developmental variation may have been due to cool temperatures.

McDonnell and Eastwood (1917), in England, recovered live larvae in the month of March, in soil three inches beneath a heap of old manure covered with grass and weeds, untouched since the previous October. Larvae were also found at the same time in a mix of dry earth and excreta at a depth of two feet. The larvae pupated within 24 hours when removed from the heap and placed in a warm room.. Emergence took place during the first week of April, some being *F. canicularis* and others being *M. domestica*, thus suggesting low winter temperatures had delayed development.

In Morocco, Charrier (1927) reported that *F. canicularis* remained abundant throughout the year and was the second most abundant of 18 common species of Diptera about habitations.

Fay (1958) does not support the findings of Roubaud and Kobayashi, since he found no evidence of diapause in his rearing studies.

Breeding media: *F. canicularis* has been found developing in a wide variety of plant and animal matter. Keilen (1919) reported rearing *F. canicularis* many times from dead snails of the following species: *Helix pomatia*, *H. aspersa*, *H. nemoralis* and *H. hortensis*.

Davis (1919) observed larvae of the little house fly feeding on grubs of the Scarabaeid Phyllophaga vehemens, but doubts this phenomenon as being a true case of predation.

Lodge (1918) reared larvae of F. canicularis on beef and mutton scraps. Larvae have also been reported in caterpillars, bumble bee nests, pigeon nests, on sugar beets, and stalks of rape (Hewitt, 1912).

Walsh (1870) maintained that decaying fruits were favorite oviposition sites for this fly, while Seguy (1950) reported this species as not seeking manure for oviposition sites, but frequently laying eggs on milk, meat, cake, fermenting substances and decaying legumes.

Nelson (1938) found larvae breeding in cracked and decomposing tomatoes in commercial tomato fields, while Sampson (1950) reported that the little house fly is a frequent pest in canneries and food processing plants, probably breeding in the waste heaps.

Otten (1944) reported an infestation of these larvae on cheese contained in crates which were broken in transit.

It is interesting to note here that both Howard (1901) and Pratt (1912) failed to list F. canicularis among the many species of flies which they reared from cow manure. Thomsen and Hammer (1936) also commented on the scarcity of the little house fly in cow barns, finding them mostly in pig and horse manure. However, Hansens et al. (1955) and Hansens and Scott (1955) reported this species as an abundant and troublesome pest on New Jersey dairy farms, though they did not specify the breeding source.

Parker (1917, 1918) collected adults of F. canicularis emerging from privies in Montana, throughout the months of July and August while Mellor (1919) collected larvae from fowl and hog manure. Miles (1946) reported that larvae can be successfully reared in the laboratory on a medium consisting of rabbit droppings and an oat-bran mixture.

Lewallen (1954) reported heavy infestations of this fly on California chicken ranches. Among the thousands of fly specimens collected by Cunningham and Little (1955) from hen manure in Alabama, F. canicularis was the third most abundant species; M. domestica ranking first and F. pusio second.

Although larvae of F. canicularis have been found in snails, caterpillars, bumble bee nests, etc., these occurrences are probably of a saprophagous nature rather than parasitic or predatory. In view of the previous statements, the breeding habits of _F. canicularis_ may be categorized as saprophagous and coprophagous.

_Adult attractants_: Several workers have mentioned attractants for adults of _F. canicularis_, but did not distinguish between nutritional or ovipositional attraction.

Gill (1955) collected _F. canicularis_ in fly traps which were baited with liver. Morrison (1948) states that fruit exudates are common sources of food for adults. In the laboratory, Lodge (1918) found honey to be a preferred food, while Illingworth (1926) reported the presence of these flies in sweet shops of Japan and Shura-Bura (1950) reported them in fruit shops of the Crimea.

Wilhelmi (1920) observed that the adults seldom frequented human foods which were exposed in the home, and that they apparently maintained themselves in such rooms by obtaining their nourishment from other sources and then re-entering. Later, he noticed the adults palpating starched curtains with their probosces.

Hansens _et al_. (1955) reported that attempts to control _F. canicularis_ with poisoned sugar baits were unsuccessful.

_Adult behavior_: Wilhelmi (1920) has devoted considerable attention to the habits of the adults; the following information being a condensation of his account. In contrast to M. domestica, the adults of F. canicularis even when present in considerable numbers seldom alight on man. For this reason, although 20-30 adults may be in a room with a sleeping person, they may not be annoying. Also, this fly does not alight on exposed human foods as regularly as does M. domestica.

Entrance to the home is probably from the sunny side of the house. After entering they engage in "play flights", which consist of circular or spinning flight paths, usually approximately one meter in diameter. This activity is commonly centered beneath a lamp, chandelier or other suspended objects in the room. The play flight of the population may endure from dawn till dusk. Oddly enough, this play flight is not interrupted by the presence or introduction of food into the room.

These play flights are not sustained in the sun, but in shaded areas. The play flight is lively and prolonged at temperatures approximating 70°F., but is reduced when the temperature is lowered to 58°F.

Upon termination of the play flight, the assumed resting position on vertical surfaces is commonly with the head downward. The night is rarely spent on hanging objects, but more frequently on the ceilings. The phototropic response appears to be positive.

Hewitt (1912) mentions these peculiar habits of this fly, and Seguy (1950) claims that the "play flight" is an activity of males only, and that they often collide while engaged in it.

Other workers who have commented on the abundant occurrence of the little house fly in the home are Lintner (1882), Graham-Smith (1914), Mellor (1919), Illingworth (1923), Sasaki (1926), McDaniel (1927), Shinoda and Ando (1935) and West (1951).

Temperature response: Shinoda and Ando (1935) in Japan mentioned that the activity of adults began at 68°F. and were most active at 78°. Wilhelmi (1920) reported that the little house fly was found in dwellings throughout the year, provided the temperature remained at or a above 57°. The play flight was active at 68°F., sluggish at 58°F., and only slight activity was noted at temperatures below 58°.

Neischulz (1935a) exposed adults to gradually rising temperature and results were as follows: acticity began at an average temperature of 40°F., feeble activity at 53°., normal activity at 60°., increased activity at 78°F., strong unrest at 93°F., heat paralysis at 104°F.

and death occurring above 105°F.. In a gradient temperature chamber, the flies congregated between 50°F. and 82°F., with the peak concentration at 70°F..

This information, supported by Table 2, James' (1947) compilation of geographical distribution records, Chillcott's (1958) statement that _F. canicularis_ has extended north, beyond the range of the house fly, suggests that this species is a "cool weather fly", capable of surviving and developing in environments which inhibit development of other domestic flies.

_Parasites and predators:_ The most common parasite in reducing populations of _F. canicularis_ is the entomophthorous fungus, _Empusa muscae_ Cohn. Graham-Smith (1916), Hesse and Hewitt (West, 1951) have all mentioned the rapidity with which this fungus decimates fly populations in the early fall months.

Two trypanosome-like flagellates, _Rhynchoidomonas fanniae_ and _R. trajecti_ were isolated from the intestines of the little house fly by Neischulz (1935b). Whether these flagellates acted as parasites or commensals in their hosts is unknown.

Hewitt reported a mite similar to _Dinychella asperata_ (Berlese), with its mouthparts inserted in the ventral abdominal areas of the little house fly (West, 1951). In 1914 he also reported the common coprophilous fly Scatophaga stercoraria as preying upon the little house fly and other muscoid diptera.

Otten (1944) reports that pupae of F. canicularis were attacked by the Ichneumon wasp, Mormoniella vitripennis (Walker), while Guibe (1945) found males of Fannia spp. as the sole prey of a colony of the wasp Oxybelus uniglumis (L.).

Leclercq (1948) presents a lucrative record, having bred Phytomyza flavicornis, Malachius bipustulatus, Pegomyia winthemi, Lonchaea lucidiventris, and Stilpnus gagates, from the larvae of F. canicularis.

## EQUIPMENT AND PROCEDURES

Collecting field adults: Satisfactory collecting of adults in the field to initiate a laboratory culture was accomplished with an aspirator (Fig. 2). This apparatus consisted of a twelve inch exhaust blower fan, powered by a 1 h. p. electric motor. A 10 ft. flexible rubber hose, 2 in. in diameter, was attached to the intake opening of the blower. A galvanized "funnel" was fitted snugly into the free end of the hose which held a pint ice cream carton with a 12 mesh screen bottom. This suction device drew resting adults into the pint carton where they were imprisoned. A long extension cord afforded mobility, allowing the operator to collect where the flies were most abundant. Screened covers were placed on the cartons and the captured adults then transferred to holding cages and returned to the laboratory.

Holding cages: The available cages at the outset of this study were constructed of wood framing and screening of Saran plastic. These cages were readily damaged and difficult to clean. The possibility of improving these cages was investigated. An experimental model made from

Fig. 2. -The use of a flexible hose attached to the intake portal of an electrically operated blower provides a rapid means of collecting resting adults. Note construction of dropping pit. (Original)

Fig. 3. -An aluminum insect holding and rearing cage. Except for the sleeve, the entire cage is aluminum. Note the sliding back panel and bracelet on front panel for sleeve attachment. (Original)

aluminum stock, which was available in local hardware stores, was constructed and proved more satisfactory. This model was further improved by the fabricators when submitted for manufacture.

The dimensions of the cage were 9 x 9 x 18 inches (Fig. 3). The bottom and both ends of the cage were formed from a single sheet of heavy gauge, sheet aluminum. The top length of the cage consisted merely of four pieces of angle aluminum, paired so that they formed two rigid braces. The screening passed between the two component parts of each brace. Attached to the back of the cage was a track which received a sliding plate of thin aluminum, 8 1/4 in. wide. The front of the cage had a circular hole 4 1/2 in., later 6 in., in diameter. A cloth sleeve was attached to the face plate with the aid of a bracelet having the same internal diameter as the hole in the face plate. Aluminum bolts tightly held the bracelet against the face plate, so that the sleeve could be pulled loose only with intentional effort. The cage was screened with 18 mesh aluminum screening. The screening was secured along the top, sides and bottom with convex aluminum flashing and aluminum bolts. With the exception of the cloth sleeve, the cage was composed entirely of aluminum.

When the cage was in use, food and oviposition media were introduced through the sleeve. At all other times a knot was tied in the sleeve, preventing escape. Removing the contents and cleaning of the cage was facilitated by sliding out the removable back panel. When allowed to soak in hot, soapy water for one half hour or longer, the cage was easily cleansed of contaminants with the aid of a stiff brush. This cage has proved to be rigid, durable, light in weight and easily cleaned, resulting in easier maintainance and versatility.

<u>Food of the adults:</u> The adults were fed two separate solutions; one of molasses and the other evaporated milk. Both were diluted with equal parts of water. These solutions were placed in 5 ounce paper cups, cut to one half their height in order to reduce the number of adults that drown while obtaining their nourishment. Each receptacle contained a crumpled piece of paper toweling, serving as an alighting surface for the feeding adults. A clean cup containing a fresh milk supply was replaced twice weekly, while additional molasses solution was added to the same container weekly.

<u>Obtaining the eggs</u>: Methods to stimulate oviposition were investigated. Although females laid a few eggs on the crumpled paper toweling in the milk container,

C.S.M.A. (Chemical Specialties Manufacturer's Association) food medium with an attractant was superior. The addition of several drops of iso-valeraldehyde, reportedly a fly attractant, to this medium failed to induce oviposition.

An extremely satisfactory, as well as inexpensive, oviposition stimulant was derived by adding household ammonia diluted with an equal amount of water to the C.S.M.A. media. The ammonia solution was added in excess to the grain medium until it was completely wetted. The excess solution was then drained off. Approximately 1 1/2 in. of this medium, placed in a 5 ounce paper cup, was highly attractive to the gravid females for a two day period.

Larval rearing: At the outset of this study, an oat-milk medium for rearing larvae was employed. This technique was discontinued after considerable effort netted only stunted larvae. Two other methods were attempted. One consisted of saturating beet pulp with equal parts of evaporated milk and water. The other method entailed mixing poultry rations with the 50% evaporated milk solution. Both of these methods proved unsuccessful.

The C.S.M.A. standard fly rearing medium was finally selected and yielded the most satisfactory results. This medium contained the following ingredients: 26% sun cured alfalfa meal, 33% soft wheat bran, and 40% dried brewers' grains. Initially these ingredients were mixed in the laboratory. Later a commercial mix prepared by the Ralston Purina Co. of St. Louis was used. This prepared medium was convenient and inexpensive. The addition of a 20% molasses solution, containing one yeast cake per 1,000 ml. to just under saturation completed the medium formulation. Approximately 1 1/2 in. of this mix placed in enameled chamber pots of 6 in. diameter was ample for rearing about one hundred larvae.

The ammoniated medium and eggs were removed from the adult holding cages and used as inoculum to initiate larval populations. The C.S.M.A.-molasses food containing the inoculum was then placed in an 80°F. temperature chamber for larval development. Temperature of the medium rose to 84°F. within three days, after which it rapidly receded and remained at 81°F..

<u>Recovering pupae</u>: Two methods of collecting pupae were designed to satisfy separate purposes. These methods are discussed as follows:

a) Cardboard method: This method was employed when it was desired to obtain pupae of a known age. When first signs of pupation were observed, tightly rolled strips of corrugated cardboard, secured with rubber bands, were introduced into the pots containing the larvae. The larvae readily crawled into the spaces between the corrugations and pupated. The pupae could then be collected at desired intervals by simply removing the rubber bands and tearing apart the laminations, whereupon the pupae were flung free onto a clean collecting surface.

b) Washing method: This was a quicker method, requiring a minimum of labor and employed when knowledge of pupal age was not necessary. When pupae were observed on the surface of the medium for a period of four to five days, the entire contents of the pot were emptied into a large sized, cone-shaped kitchen strainer constructed of 12-mesh screening. This was then placed over a pail and washed with cold, running water. When the bucket became filled with water, agitation of the strainer cleaned the medium of the alfalfa meal, molasses, flakes of bran and decomposition products. The force of the falling water from the faucet provided a churning action which aided the cleaning process. The water in the pail was emptied several times and when the water in the pail no longer became discolored by the debris, the cleansing operation was considered complete. Usually only the pupae and the hulls of brewers' grains were left behind. By slowly raising and lowering the strainer, the pupae and hulls settled to the bottom of the cone, whereupon they were removed with the aid of a soup spoon and placed into paper food containers of 5 ounce capacity.

Seasonal distribution records: Taking advantage of the fact that this fly selects a hanging object under which to conduct its "playflight" activities (Fig. 18), a common sticky fly ribbon was employed. This method proved satisfactory beyond expectations. Even in mixed fly populations, the number of domestic flies captured, other than *Fannia*, on these suspended ribbons constituted only a small percentage of the total.

The Aeroxon fly ribbons utilized for this purpose were 1 1/2 in. wide and 2 1/2 ft. long. The packet included a thumb tack for attachment. The adhesive qualities lasted up to seven days, depending on conditions. The ribbons were suspended in the midst of the flies' "play-flight" activities. The encircling flies readily alighted on the sticky paper (Fig. 19).

# EXPERIMENTS AND OBSERVATIONS

## LABORATORY STUDIES

Life cycle: Oviposition medium with eggs was removed from holding cages as the eggs were observed and placed in the C.S.M.A. medium. The organisms were inspected daily. When the first mature larvae were observed, tight rolls of corrugated paper were placed on the surface of the medium and removed the following day when the corrugations became occupied by ten or more larvae (Table 3). These rolls were placed in cages and the pupal period recorded when the first flies were observed, although a few may not have emerged until 24 hours later.

Considering the pre-oviposition period as being 4-5 days (Table 9), a total of 23-25 days is required for development from egg to egg. These data compare favorably with those of Table 2, but more closely represent the minimal time required for a complete egg to egg cycle.

When first instar larvae were maintained at 48°F., adults emerged approximately five months later. They did not develop at 90°F. Thus the low effective range of this species accounts for its ability to develop gradually during the winter months at the low manure temperature found in dropping pits.

TABLE 3

LENGTH OF DEVELOPMENTAL STAGES OF F. canicularis FROM EGG TO ADULT, WHEN REARED IN A MODIFIED C.S.M.A. MEDIUM AT 80°F. IN THE LABORATORY

| Lot | No. of Days: Egg | Larvae | Pupae | Total |
|---|---|---|---|---|
| A | $1\frac{1}{2}$-2 | 9 | 10 | 21 |
| B | " | 8 | 9 | 19 |
| C | " | 8 | 9 | 19 |
| D | " | 8 | 9 | 19 |
| E | " | --- | --- | --- |
| F | " | 10 | 10 | 22 |
| G | " | 10 | 10 | 22 |
| H | " | 10 | 10 | 22 |
| I | " | 9 | 10 | 21 |

<u>Size of immature stages</u>: Lewallen (1954) stated that the instars could be differentiated by the degree of melanism in the cephalo-pharyngeal skeleton (p. 12). This was found unreliable, since the extent of coloration in the mouthparts of very small larvae was not as Lewallen had stated. An accurate method for instar

determination entailed dissecting and comparing the morphology of the cephalo-pharyngeal skeleton (Fig. 4). However, this method is tedious. A more convenient procedure, though probably not as exact, is by linear measurements (Table 4).

TABLE 4

THE LENGTH IN MM. OF THE IMMATURE STAGES OF F. canicularis WHEN REARED IN C.S.M.A. MEDIUM AT 80°F.

| Stage | Sample size | Maximum | Minimum | Average | Lewallen's data (1954) |
|---|---|---|---|---|---|
| Egg | 50 | 0.95 | 0.80 | 0.88 | 2.0 |
| 1st * | 25 | 1.10 | 0.80 | 1.00 | 1.5 |
| 2nd | 25 | 3.20 | 2.60 | 2.80 | 3.0 |
| 3rd | 50 | 7.50 | 5.80 | 7.00 | 6.7 |

* Instar

No explanation can be offered concerning the discrepancies between Lewallen's (1954) egg measurements and those obtained in this laboratory.

Development of cephalo-pharyngeal skeleton: Since several ecological factors may account for undersized specimens, determination of larval instars by linear measurement may not be accurate. A more exact method of determining larval instars is to dissect and examine the morphology of the cephalo-pharyngeal skeleton (Fig. 4).


Fig. 4 -Morphological development of the cephalo-pharyngeal skeleton of F. canicularis. 1, dental sclerite; 2, mandibular sclerite; 3, hypostomal sclerite; 4, pharyngeal sclerite; 5, dorsal cornua; 6, ventral cornua. Actual sizes: 1st. instar, 0.2 mm; 2nd. instar, 0.8 mm. and 3rd. instar 1.1 mm.

The first larval instar can be distinguished by the absence of a heavily developed pharyngeal sclerite, slender, smooth mandibular sclerites, absence of the dental sclerite and an uninterrupted crescent arc between the dorsal and ventral cornuae.

The second larval instar is distinguished by a thickening of the pharyngeal sclerite, irregularities in the smoothness of the posterior mandibular sclerite and a blade-like intrusion into the arc between the dorsal and ventral cornuae.

The third instar is distinguished by the well developed pharyngeal sclerite, presence of the dental sclerite and the coalescence of the blade-like intrusion with the ventral cornuae.

<u>Identification aids</u>:

The egg: The chorion is milky white, approximately 1 mm. in length and possesses two wing-like processes which extend laterally along its length. The dorsal aspect is characterized by deeply embossed reticulations which are somewhat hexagonal in outline. A mid-dorsal ridge is visible.

The egg is asymmetrical when viewed laterally; the posterior portion being wider, the anterior portion much narrower. The lateral and ventral aspects possess longitudinal ridges which extend discontinuously the length of the egg.

The larva: The larval description offered by Greene(1956) (p. 11), is incomplete, since it lacks a few essential characters which would distinguish it from F. scalaris, a closely allied species frequently found in the same environment with F. canicularis. A tabular presentation of the morphological differences is given to aid in distinguishing between the larval forms of the two species (Table 5).

TABLE 5

AIDS IN DISTINGUISHING BETWEEN THE LARVAE OF F. canicularis AND F. scalaris IN THE FIELD

| Character | F. canicularis | F. scalaris |
|---|---|---|
| Lateral Processes | Abdominal lateral processes spinulose only basally; not pinnate (James, 1947) (Fig. 5) | Abdominal lateral processes pinnately branched, almost to the apex (James, 1947) |
| Abdominal Sternites | Ventral abdominal sternites bearing a median, transverse carina (Fig.23) | Ventral abdominal sclerites smooth, lacking a transverse, median carina |
| Posterior Processes | Processes on last abdominal segment, not all equal in length (Fig.5) | Processes on last abdominal segment approximately of equal length. |

Usually, larvae collected in the field are encrusted with debris, making it difficult to distinguish the two species by the morphology of their processes, as stated by James (1947). In these instances, it has been found that visual inspection of the ventral abdominal sternites will quickly indicate the identity of the specimen at hand (Table 5). Fannia scalaris was the only closely allied species of F. canicularis that was encountered during the study.

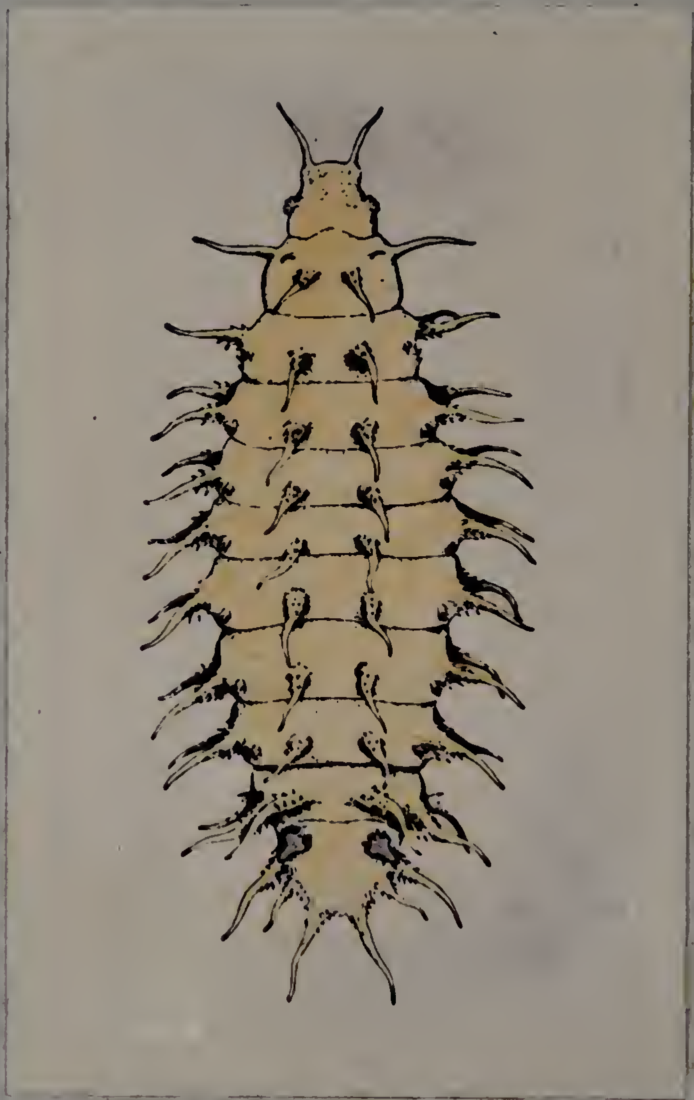


Fig. 5- Larva of F. canicularis. Note the presence of the small, dark spines around the base of the abdominal processes, and the two shorter processes on the last abdominal segment. These characters aid in distinguishing this larva from a closely allied species, F. scalaris. (After Hewitt, 1912)

The pupa: The pupal description (p. 13) given by Lewallen (1954), is brief and not intended to distinguish this pupa from pupae of other species but only from the other immature stages of the little house fly. His description is sufficient for this purpose. In some cases, however, it is desirable to distinguish between F. canicularis and F. scalaris since the two species occur simultaneously in the same environment. The lateral processes of the larva become dried and shriveled in the pupal stage and hence are of no value in identification of the specimens. Alternative characters that can be used are the ventral sternites and the anal openings (Table 6).

TABLE 6

AIDS IN DISTINGUISHING THE PUPA OF F. canicularis FROM F. scalaris

| Character | F. canicularis | F. scalaris |
|---|---|---|
| Abdominal Sternites | Ventral abdominal sternites bearing a transverse, median carina. (Fig. 23) | Ventral abdominal sternites lacking a transverse, median carina. |
| Anal Opening | Anal opening bordered by a raised fold forming a V (Fig. 23). | Anal opening oval in outline, not bordered by a raised fold forming a V. |

The adult: The description of the adult by Graham-Smith (1914) is adequate (p. 10). A compilation of the major differences between Musca domestica and Fannia canicularis will enable one to distinguish the two species in the field more readily (Table 7).

TABLE 7

AIDS IN DIFFERENTIATING ADULTS OF Fannia canicularis FROM Musca domestica IN THE FIELD

| Character | Musca | Fannia |
|---|---|---|
| Length | 7 mm. | 6 mm. |
| Venation | 4th longitudinal vein bent sharply,apparently closing the 1st posterior cell. | 4th longitudinal vein straight, 1st posterior cell open (Fig. 7). |
| Abdominal Coloration | Greyish-black, yellow patches lacking. | Dull black with yellow buff.patches on the basal-lateral aspects of the male and only basally on the female (Fig. 6). |
| Thoracic Stripes | Four prominent shiny black stripes. | Three, brownish-black stripes, more prominent on female. |
| Wing Position | Wings held apart when resting, forming a broad V. | Wings held close together when resting forming a narrow V. |
| Flight Habits | Quick, dart-like; in broken lines. | Slow, commonly found congregating and circling in play flights beneath suspended objects. |

Fig. 6- An adult male of F. canicularis, showing the light yellow abdominal patches. On live specimens, the wings overlap greatly, giving the fly a more narrow appearance. (After Hewitt, 1912)

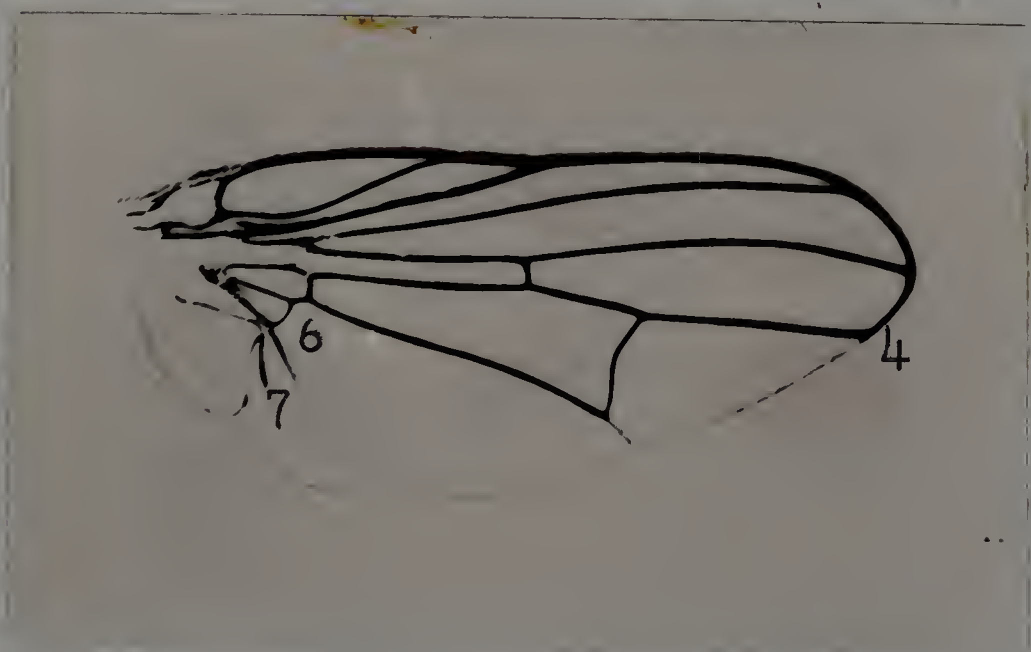



Fig. 7- Wing of F. canicularis. Note that the 4th longitudinal vein is relatively straight, not bent sharply anteriorly as in M. domestica, and the curving of the 7th vein around the apex of the 6th. (After Hewitt, 1912)

Ability of eggs to withstand low temperatures: Eggs of the little house fly were observed in the field in the early and latter parts of the year when cool temperatures prevailed.

Twenty-five newly deposited eggs were placed on chicken manure in a 5 ounce paper cup and kept in an outdoor weather shelter with a maximum-minimum thermometer alongside the cup.

Despite low air temperature, often below freezing, 68% of the eggs hatched on the 24th and 25th days. (Table 7). The balance of the eggs had collapsed.

TABLE 7

ABILITY OF 25 EGGS OF *F. canicularis* TO WITHSTAND LOW OUTDOOR TEMPERATURES

| Date | Air Temp.-°F. | | | No. Hatch |
|---|---|---|---|---|
| | Maximum | Minimum | Mean | |
| March 29* | 54 | 31 | 42.5 | * |
| April 1 | 60 | 24 | 42.0 | 0 |
| " 2 | 54 | 46 | 50.0 | 0 |
| " 3 | 48 | 30 | 39.0 | 0 |
| " 4 | 46 | 34 | 40.0 | 0 |
| " 5 | 42 | 32 | 37.0 | 0 |
| " 8 | 48 | 34 | 41.0 | 0 |
| " 9 | 46 | 32 | 39.0 | 0 |
| " 10 | 48 | 30 | 39.0 | 0 |
| " 11 | 50 | 33 | 41.5 | 0 |
| " 13 | 42 | 42 | 42.0 | 0 |
| " 14 | 48 | 33 | 35.5 | 0 |
| " 15 | 53 | 26 | 39.0 | 0 |
| " 16 | 62 | 29 | 45.5 | 0 |
| " 17 | 58 | 46 | 52.0 | 0 |
| " 22 | 84 | 38 | 61.0 | 11 |
| " 23 | 80 | 46 | 63.0 | 6 |

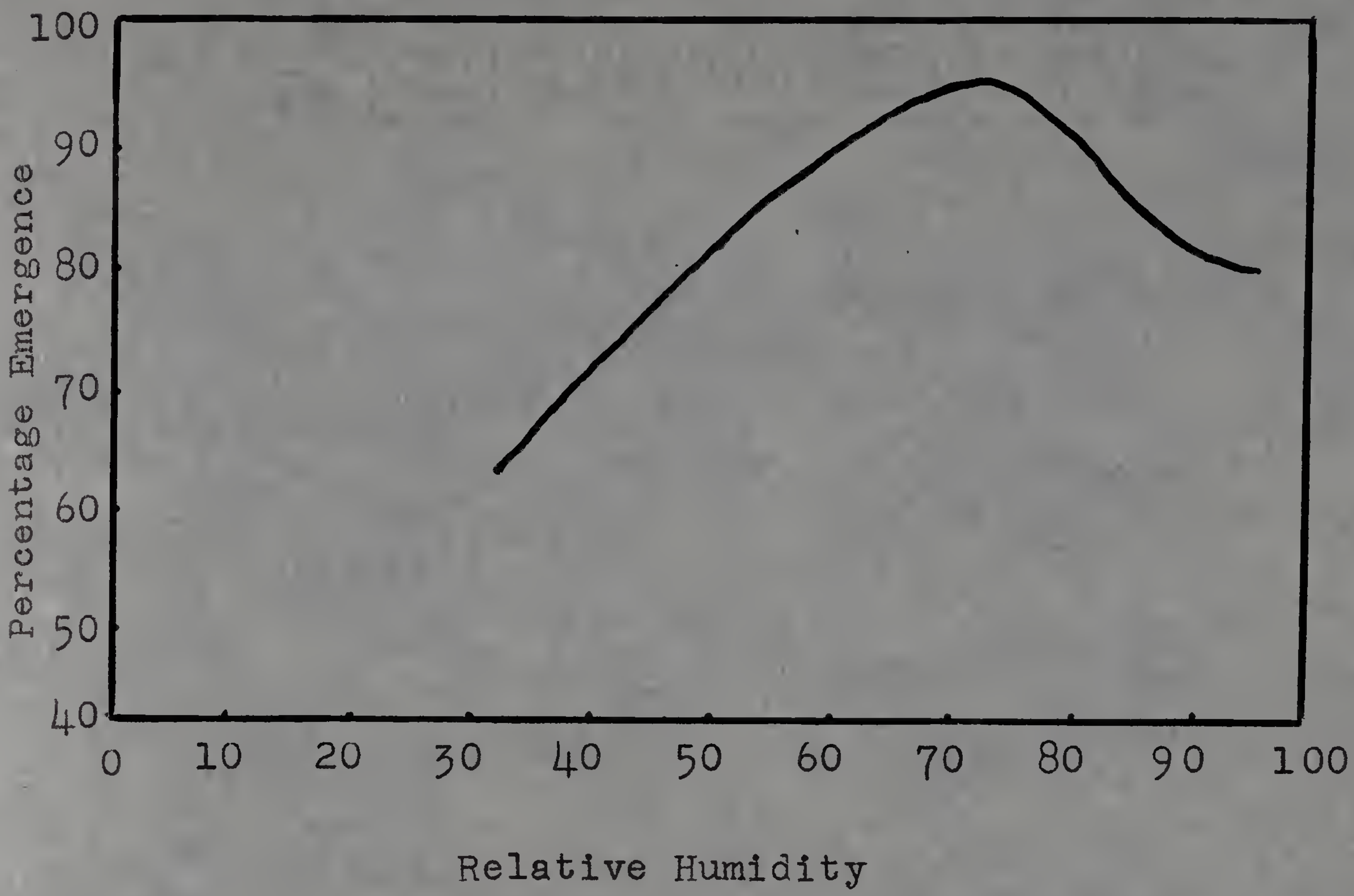
* Date of Initial Exposure

Effect of relative humidity on emergence from pupae: Both in the field and in the laboratory, mature larvae migrated from the moist breeding medium to drier enviornments in which to pupate (Fig. 8).

Controlled humidity chambers were established with saturated salt solutions in glass-top fruit jars. The relative humidity levels were 32%, 56%, 63%, 77%, 84%, and 97%. Snugly fitted in the mouth of these jars were 5 ounce paper cups with perforated sides containing 20 mature larvae. Rubber jar rings were used to obtain air tight seals. These units were replicated four times for each humidity level and placed at 80°F. (Fig. 9).

Fig. 8 -Maturing larvae seek drier environments for pupation. Here, the darkened areas along the base of the wooden wall are caused by an accumulation of pupal skins, indicating the migration of mature larvae from a pit which is on the other side of the wall. (Original)

Fig. 9 -The effect of relative humidity on development of pupae and emergence of flies of F. *canicularis* at 80°F.




The optimum moisture needs for pupal development and emergence of flies at 80°F. appears to be near 70%-75%. The effective range extends beyond 32% and 97%.

Adult emergence: The adult develops from a coarctate pupa, which is compressed dorso-ventrally, similar to the larva. The morphology of this puparium is atypical when compared with that of other muscoid flies. Consequently, emergence occurs in a slightly dissimilar fashion.

The internal pressure, caused by the expansion of the ptilinum, causes two lines of dehiscence to develop anterolaterally and posteriorally to the fifth segment, where these lines develop slightly dorsally. The area encompassed by these separations forms a dorsal flap only, which remains attached to the puparium as the adult extricates itself.

The newly emerged adult is light grey, except for its bristles, which are black. The abdomen is somewhat reduced in size with the wing pads extending almost to its tip. The fly moves about rapidly for short distances in various directions and occasionally inflates the ptilinum briskly. Meanwhile, melanism increases on the legs, thoracic and abdominal areas and the three dark thoracic stripes become visible.

This newly emerged fly continues this performance for 15-18 minutes, then remains motionless as the wing pads and abdomen are inflated. Complete extension of the wings is rapid, requiring one to two minutes. When viewed cross sectionally, both wing surfaces are convex. However, they flatten and harden quickly and the adult is capable of flight within 25 minutes after emergence.

<u>Sex ratio of adults</u>: Freshly collected laboratory pupae were placed singly in cork-stoppered, three-dram vials. As the adults emerged from the pupal cases, their sex was distinguished by abdominal coloration and the

relative distances between the eyes. The sex ratio of this population was approximately 0.5 (Table 8).

TABLE 8

SEX RATIO OF ADULTS OF *F. canicularis* FROM 74 PUPAE

| Total | No. Females | No. Males | Percentage of Females | Percentage of Males |
|---|---|---|---|---|
| 74 | 36 | 38 | 49 | 51 |

Reproductive capacity: To determine the reproductive capacity of this species, freshly collected, laboratory pupae were placed singly in cork-stoppered three-dram vials. Four pairs of (male and female) flies which emerged on the same day were introduced into separate aluminum rearing cages.

Diluted household ammonia was added to dry C.S.M.A. medium in five-ounce paper cups and introduced into the holding cages. This served as an attractive oviposition site. Evaporated milk, diluted with equal parts of water, was placed in the cages as food for the flies.

The cups containing the ammoniated medium were collected 5 days after the entrance of the flies and thereafter were replaced periodically. The eggs were collected and counted with the aid of a microscope (Table 9).

TABLE 9

THE NUMBER OF EGGS LAID BY FOUR FEMALES OF *F. canicularis*

| Days After Emergence | No. of Eggs Oviposited | | | |
|---|---|---|---|---|
| | A | B | C | D |
| 5 | 0 | 44 | 14 | 9 |
| 12 | 36 | 74 | 98 | * |
| 15 | 32 | 31 | 29 | - |
| 22 | 162 | 0 | 35 | - |
| 25 | * | * | 37 | - |
| 27 | - | - | * | - |
| Total | 230 | 149 | 213 | 9 |

* Females found dead.

Previous observation indicated that no eggs were oviposited four days after emergence. In accordance with this observation and data in Table 9, the preoviposition period was estimated to be four to five days and that females of this species may lay about 200 eggs.

<u>Attraction of manures</u>: To determine the attractiveness of manures to this fly, freshly voided samples were placed in individual paper cup and exposed collectively in cages containing gravid females. This procedure was replicated four times. Counts of the eggs in each medium were made after four days (Table 10).

TABLE 10

THE NUMBER OF EGGS SELECTIVELY OVIPOSITED ON FRESHLY VOIDED ANIMAL MANURES BY *F. canicularis* UNDER CAGED CONDITIONS

| Manure Source | Eggs Per Cage | | | | Totals | Percentage of Total at 4 Days |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | | |
| Chicken | 185 | 470 | 53 | 1000 | 1708 | 63.5 |
| Hog | 57 | 380 | 0 | 166 | 553 | 20.5 |
| Horse | 170 | 64 | -- | -- | 234 | 8.7 |
| Cow | 103 | 3 | 0 | 4 | 110 | 4.0 |
| Sheep | 28 | 2 | 0 | 53 | 83 | 3.0 |

A preference for hen manure was evidenced as 63.5% of the total number of eggs oviposited were on this material. However, this preference was not exhibited in all cages to the same degree. Sheep manure had little attraction for oviposition. The high ammonia content associated with chicken manure, since it contains both urinary and intestinal wastes, may be the attractive factor.

To disclose whether the chicken manure retained or lost its attractiveness upon standing, as a preferred oviposition medium, the manure samples from cage #1 (Table 10), were retained in the cage for a period of seven additional days. The eggs oviposited on each medium were collected and counted with the aid of a microscope ( Table 11).

TABLE 11

NUMBER OF EGGS OVIPOSITED ON ELEVEN DAY OLD ANIMAL MANURES BY *F. canicularis* WHEN PLACED IN A CAGE WITH GRAVID FEMALES

| Manure Source | Number Of Eggs | Percentage Of Total |
|---|---|---|
| Hen | 1,000 + | 51.4 |
| Horse | 280 | 16.0 |
| Cow | 200 | 11.4 |
| Hog | 180 | 10.3 |
| Sheep | 80 | 4.5 |

The hog, sheep and horse manure dried considerably after the third day of exposure, while the cow and chicken manures retained moisture for a longer period. Again, the females displayed a preference for the chicken manure, over the other manures offered, as an oviposition site. This is in line with field observations and collections (Table 22).

Longevity of adults: Pupae were placed in paper dishes and then introduced into a holding cage containing food and oviposition medium. The cage was placed in temperature chamber at 80°F. Approximately 150 adults emerged within a two day period, July 31 and August 1, after which the remaining pupae were removed. The dead flies were removed from the cage bottom at weekly intervals and the sexes noted (Fig. 10).

Almost half of the population was dead 15 days after the emergence date. Of these dead individuals, 77% were males. Nearly the entire population was dead 28 days after emergence. Females survived longer than males; the greatest length of life being 54 days.

Larval phototropism: To determine the larval phototropic response, the following procedure was employed. The four points of the compass, N., E., S., and W. were marked on the four sides of a two-square-foot section of grey cardboard, then the light from an American Optical Co. microscope lamp was directed through a water-filled Erlenmeyer flask onto the cardboard. The light did not increase the temperature on the cardboard. The light source originated two inches above the table level. A cup containing 25 larvae was inverted on the illuminated cardboard. The cup was removed and the subsequent orientations of the larvae were recorded as the cardboard was rotated before the light source (Table 12). The larvae displayed a definite negative phototropism.

Fig. 10 -Survival of male and female flies in relation to age of population @ 80°F.

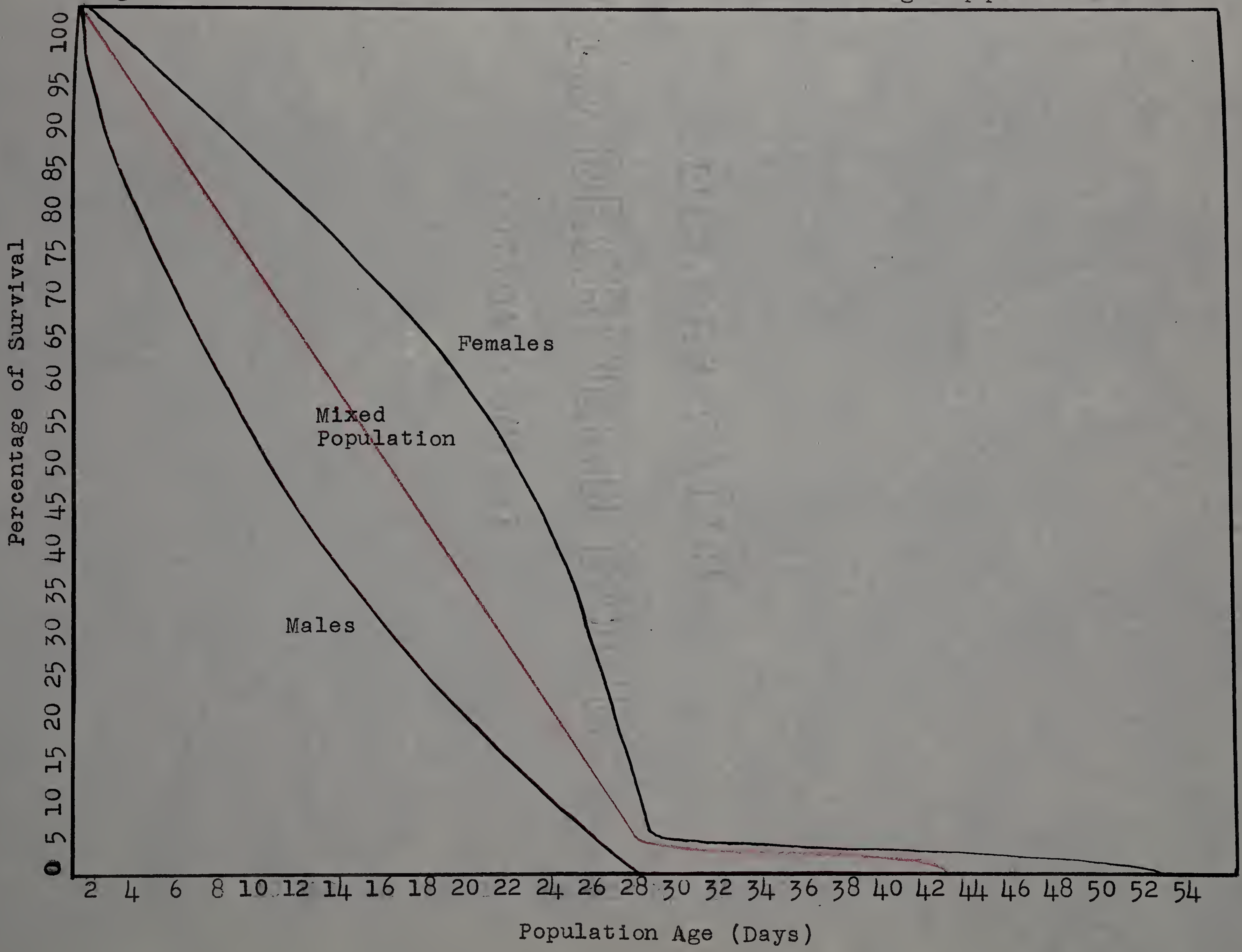


TABLE 12

ORIENTATION OF *F. canicularis* LARVAE
TO DIRECTIONAL LIGHT

| Direction of Larval Movement | Source of Light Beam | Directional Response to Light Source | Orientation Response in Degrees |
|---|---|---|---|
| East | North | South | 90 |
| South | East | West | 90 |
| West | South | North | 90 |
| North | West | East | 90 |
| North | North | South | 180 |
| South | South | North | 180 |

Adult phototropism: A cage containing approximately 250 unsexed flies was placed in such a manner that a beam of light from an incandescent lamp shone on it from one side. This light source was the sole illumination falling on the cage. The cage was turned 180° every three minutes, thus allowing ample time for excited flies to alight and be observed. This was repeated five times. Most of the flies were positively phototropic throughout the test.

Anemotropism: The activities of the flies in sheltered habitats suggested that they might be sensitive to air currents. In the laboratory, approximately 100 adult caged flies were subjected to air blasts emanating from a high speed, rotary impeller.

An anemometer in the cage registered the velocity of air flow through the cage in ft. per minute for five minute periods. The activity of the flies was noted as the cage was moved progressively closer to the source of the air blast (Table 12). At the higher air speeds, the sedentary flies were disturbed from their resting places by insertion and movement of the hand inside the cage. This enabled observations on the stability of flight at the higher velocities.

TABLE 13

THE EFFECT OF WIND VELOCITY ON THE ACTIVITY OF *F. canicularis* ADULTS IN THE LABORATORY

| Wind Velocity In M. P. H. | Observations |
|---|---|
| 3.2 | Flies actively flying in cage. No reduction in activity noted. |
| 5.8 | Slight reduction in numbers flying. |
| 9.8 | Noticeable reduction in flight activity. Flies walking briskly. Flight against air current normal. |
| 12.1 | Few flies in flight. Most resting on cage; the wings fluttering in air current. Flight unstable. |
| 13.8 | Flies clinging to cage. No voluntary flight. Flight of disturbed flies very unstable. |
| 16.6 | Complete cessation of all movement. All flies clinging to cage. Disturbed flies at mercy of air current. |

The adult flies were apparently curtailed in their activities at wind velocities of 9.8 m. p. h. and above. At 12.1 m. p. h., flight activity was greatly reduced; the few flies venturing into the wind were capable of directional flight but with difficulty. All flight activity ceased when the wind velocities approximated 16 m. p. h..

## FIELD STUDIES

Food of adults: Fresh milk did not attract this species. On farm # 18 (Table 14), pans of milk were exposed during the day, serving as food for several cats on the premises. Although this milk was in the same room where circling flies were numerous, adults were not observed feeding on this milk. At the University dairy barn, pans of milk containing Malathion did not attract the flies. It was concluded that these flies were not readily attracted to milk in the field. In the laboratory, the flies did not swarm to cups containing milk.

In early June, 1958, adults were found feeding on aphid honeydew deposits on leaves of a neglected apple tree. On May 1, 1957, many adults were observed feeding on pear blossoms, in an orchard close to a poultry house. These adults were feeding on nectar exudates, since there were no aphids on these trees.

In the laboratory, adults swarmed around cups containing diluted honey. These observations indicate that odiferous sweets are attractive as food for adults.

Poultry farm inspections: During the winter of 1957-1958 poultry farms across the state of Massachusetts, as well as several in neighboring states, were visited to accumulate information regarding the ecological conditions under which the little house fly became abundant. The locations of these establishments are shown in Fig. 11.

Management practices encountered: Management practices have a direct effect on insect populations. Several types of manure management were encountered during the farm inspections (Table 14). They may be described as follows:

Open floor: Open floor management does not involve any roosting facilities. Layers of litter are placed on the floor to a depth of three inches or more. This litter receives the hen droppings. It must be kept fairly loose and dry through the addition of lime, tilling, and addition of more litter if necessary.

Few farms employ this system because of the initial and replacement cost of the litter and the


Fig. 11 -Approximate locations of poultry farms visited in Massachusetts and adjoining states.

constant attention it requires. Another disadvantage is that it affords a maximum exposure to parasites and disease organisms which may be present in the dropping-litter conglomeration.

Dropping boards: In this system, one uses large rectangular, horizontal surfaces, raised above the floor level permitting scratch space beneath. Above this platform is the roosting surface, made of slats and chicken wire. The voided waste falls through the wire onto the dropping boards. The boards must be cleaned of the dropping accumulations every two weeks or so.

The advantage of this system is that it does not consume floor space. Also the droppings are isolated from the litter, thus increasing sanitation and conserving the litter texture.

Caged layers: This is a fairly recent innovation in the poultry industry in which individual hens, or small numbers of them, are confined in cages in batteries three or four tiers high. Often present between each tier of cages is a sheet of heavy paper emanating from a roll secured at one end of the battery. Droppings from the hens fall through the cage onto the paper which is pulled from the roll and discarded.

TABLE 14.- MANAGEMENT PRACTICES AND INFESTATIONS OF *F. canicularis* ON POULTRY FARMS VISITED IN MASSACHUSETTS AND ADJOINING STATES DURING THE WINTER OF 1957-1958

| Farm No. | Date Visited | Management Of Droppings: Collection | Cleaning Interval* | Date Last Cleaned* | Stages Detected | Pupal Skins Detected | Estimate Of Population |
|---|---|---|---|---|---|---|---|
| 3 | 1-21-58 | Drop Boards | 2 Weeks | Nov. 24 | None | None | None |
| 8 | 1-28-58 | Drop Boards | 2 Weeks | Jan. 13 | " | " | " |
| 2 | 1-21-58 | Open Floor | Yearly | March | " | " | " |
| 6 | 1-27-58 | Open Floor | Yearly | April | " | " | " |
| 11 | 3-3-58 | Open Floor | Yearly | March | " | " | " |
| 15 | 2-6-57 | Open Floor | 4 Months | ? | " | " | " |
| 16 | 2-6-57 | Open Floor | Yearly | April | " | " | " |
| 17 | 2-6-57 | Open Floor | Yearly | ? | " | " | " |
| 27 | 4-16-58 | Open Floor | Yearly | ? | Adult | Inconspicuous | Medium |
| 32 | 2-11-58 | Cage Trap | Monthly | Jan. | Adult | Inconspicuous | Light |
| 1 | 1-21-58 | Pits | Monthly | Dec. 30 | None | None | None |
| 4 | 1-21-58 | Pits | 2 Months | Nov. 3 | Larvae 3rd | Inconspicuous | Light |
| 5 | 1-27-58 | Pits | Monthly | Dec. | " " | " | " |
| 7 | 1-28-58 | Pits | 3 Months | Oct. | " " | Conspicuous | Medium |
| 9 | 1-28-58 | Pits | 2 Months | Nov. | " " | " | Light |
| 10 | 2-24-58 | Pits | 2 Months | Nov. | " " | " | Heavy |
| 12 | 3-3-58 | Pits | 3 Months | Oct. | Lar. & Adult | Inconspicuous | Light |
| 13 | 3-3-58 | Pits | 3 Months | Oct. | " " | Abundant | Heavy |
| 14 | 4-4-57 | Pits | 3 Months | Oct. | " " | " | " |
| 18 | 1-21-58 | Pits | 4 Months | Oct. | " " | " | " |
| 19 | 4-2-57 | Pits | 3 Months | Nov. | " " | Conspicuous | Medium |
| 21 | 2-7-57 | Pits | 2 Months | Dec. | Larvae | Inconspicuous | Light |
| 22 | 2-7-57 | Pits | 3 Months | Nov. | " | " | " |
| 23 | 3-7-57 | Pits | 4 Months | Oct. | " | Abundant | Heavy |
| 24 | 3-10-58 | Pits | 3 Months | Nov. | None | None | None |
| 25 | 4-16-58 | Pits | 6 Months | Oct. | Lar. &Adult | Conspicuous | Heavy |
| 26 | 4-16-58 | Pits | 6 Months | Oct. | " " | Inconspicuous | Medium |
| 30 | 2-11-58 | Pits | 6 Months | Oct. | Larvae | Conspicuous | Light |
| 31 | 2-11-58 | Pits | Yearly | April | Lar.&Adult | " | Medium |

* Approximate Dates

This system has the advantage that it increases the available floor space three or four times and no litter is necessary on the floor. Also parasite infections are minimal, and cleaner eggs are produced. Disadvantages are the initial cost of equipment and frequent manure removal.

Pit system: The system encountered most frequently on poultry farms was the pit system. This system employs a pit, one to two feet deep, underneath the roosts. The voided hen manure drops into these pits where it is allowed to accumulate for periods ranging from one to twelve months (Figs. 2 & 12).

This system is popular with farmers because the bulk of the manure is collected in a given area and a minimum contamination of the litter occurs. Also, the manure may be allowed to accumulate for long periods, even as long as a year if the pits are constructed deep enough, reducing the expense of frequent removal.

Of the 32 establishments visited, 19 employed the pit system, seven the open floor, two the dropping board and one the caged layer system (Table 14).

Fig. 12 -Two poultry farms experiencing heavy infestations of F. canicularis and utilizing raised pits, were visited. Since water and feed troughs were placed on these raised structures, the bulk of the droppings were collected below them in the pit. However, spillage of water by the hens kept the manure moist, undoubtedly increasing the seriousness of the infestation during summer months. (Original)

Overwintering stages present in poultry houses: All stages of this fly except the egg were found during the w inter months in a number of poultry houses. The predominant forms were the third larval instar and pupae (Table 14).

The adults occurred only in small numbers. On colder days (under 39°F.) careful scrutiny revealed them in cracks and crevices. When disturbed, they were extremely sluggish and flew with considerable difficulty. On days when the air temperature in the pens reached above 40°F., adults were seen flying sluggishly about of their own volition.

Here again is displayed the ability of this species to persist in its activity at low temperatures. The low affective temperature range of this fly probably accounts for its geographical distribution poleward where other domestic flies are unable to survive.

Larvae of the little house fly were the only muscoid larvae encountered during the winter inspection.

<u>Pupal skins as indicators of previous infestations</u>: The presence of pupal skins in poultry houses may serve as an indication of the degree of previous infestation (Table 14).

On farms that had heavy infestations, an abundance of pupal skins was usually conspicuous. They were at the periphery of the breeding source (Fig. 8). The skins may accumulate in these characteristic localities in layers approximating 1/4 inch in thickness.

On several farms, these skins were in such abundance that they formed piles four to five inches deep on ceiling beams which were directly beneath heavily infested pits. In these cases, the larvae had worked their way through cracks in the floor when seeking pupation sites. Infestations on these farms were easily detected, since the accumulations of pupal skins were not disturbed in the seasonal cleaning operations.

Estimating populations: The degree of infestation on these farms was based primarily on evidence other than the presence of adults (Table 14). The evidence of degree of infestation was separated into four categories, as follows:

None: No evidence of larvae, pupal skins or adults was detected.

Light: Pupal skins inconspicuous, only few larvae or adults detected.

Medium: Pupal skins conspicuous, larvae easily detected but occurring in pockets.

Heavy: Pupal skins abundant, larvae easily detected and occurring quite uniformly around the periphery of pits.

Effect of manure management practices on fly populations: Of the 19 farms employing the pit system, six were considered as harboring heavy infestations of the little house fly, four as medium, and seven as light; and on two farms evidence of this fly was not detected (Table 14).

There are several features of this system which are conducive to large fly populations. The large accumulations of concentrated manure keep this medium relatively moist and considerable warmer than the surrounding air (Fig. 2 & 12). Also these accumulations are undisturbed for extended periods. Thus, although freezing or near-freezing temperatures may occur in the pens, the sheltered habitat in the pits afford the necessary warmth, food, and moisture necessary for maintenance of the overwintering larvae. It is important to note that all farms which were marked as heavily infested employed the pit system.

Of the seven farms visited which employed the open floor system only one was considered as supporting a medium fly infestation. On the other six farms traces of such populations were not detected (Table 14). In order that the litter serve as a functionally absorptive medium, it must be maintained, either by tillage, addition of more material, adequate ventilation, etc.. Practices such as these maintain the litter in a condition which is not conducive for the development of larval forms.

This type of management, when effectively practiced, appeared to be the most effective system in preventing large fly populations (Tables 14 & 15).

TABLE 15

NUMBER OF ADULTS OF *F. canicularis* CAPTURED ON FLYRIBBONS HUNG IN PLACE FOR HALF-HOUR PERIODS IN HALLWAYS ON A FARM EMPLOYING OPEN FLOOR MANAGEMENT AS COMPARED WITH A FARM EMPLOYING THE PIT TYPE OF MANAGEMENT - 1958

| | No. Flies Captured | |
|---|---|---|
| Date | Pit System | Open Floor System |
| April 23 | 390 | 1 |
| May 9 | 470 | 4 |
| Total | 860 | 5 |

Because of the geographic location of farm #11 (Table 14), it was not convenient to visit it frequently to obtain additional data for a more substantial comparison. However, it was obvious that on the dates when farm # 18 had considerable numbers of this fly, farm # 11 had negligible amounts. The fly problem at the farm using the open floor system was at a minimum throughout the season and was considered as a model farm by the county agent. The scarcity of adults on farm # 11 was attributed to the looseness and dryness of the litter maintained by the farmer.

Neither of the two farms which employed the dropping board systems revealed any evidence of the presence of the little house fly (Table 14). This may be the result of frequent removal of manure from the boards because of their limited capacity.

Since the caged layer system was in operation on only one of the farms visited, and the manure not handled as recommended, its role in nurturing fly populations would be mere conjecture. The key feature of this system which can discourage population increases is frequent manure removal. On the farm visited, removal paper was not utilized between tiers. In its place was unmovable sheet metal. The proprietor complained of difficulties when removing the manure each month because of the limited space between tiers. Although no larvae were found in the manure, inconspicuous pupal skins and a few adults were detected.

Timely removal of manure accumulations can reduce infestations drastically. Although a few adults may overwinter in the poultry houses, the major source of the succeeding year's infestation is from the overwintering larval population within the accumulation of manure.

Frequent removal and proper disposal of the manure collected in pits will remove and destroy many of the developing larvae. On two farms which utilized dropping boards, indications of little house fly populations were lacking. On farms #1 and #5, which used pits but cleaned them monthly, the indication of infestations were also inconspicuous.or lacking.

However, five of the six farms which had heavy infestations used the pit system and allowed an interval of three months or more between cleanings (Table 14). On these five farms, the manure in the pits had accumulated since October. Since the females continue oviposition throughout October and into early November, these manure accumulations were capable of being infested with eggs from females of the fall populations.

According to county agents, barn type chain cleaners, such as the Jamesway, are available for poultrymen who use pits. With this machine, all the manure throughout the poultry house can be cleaned daily simply by pressing a button. Although most poultrymen cannot afford the initial cost of such an installation, some larger operators have already done so. On these farms, fly populations should be at a minimum.

Cleaning pits is a tedious and costly operation for the poultryman and he is reluctant to shorten the interval between cleanings. Because of these factors, poultrymen should be aware of the following fact:

manure should not be allowed to accumulate in the pit from late fall to early spring, but should be cleaned in late January in order to obtain reduction of the potential infestation of this fly during the forthcoming season. Farmers seriously attempting to combat this fly should realize the economic benefits from this single operation. Also, where practical, weekly cleaning of manure accumulations will tend to reduce populations.

Temperature in manure pits: The accumulation of manure in pits is conducive to maintainence of fly populations, mainly because it offers food, moisture and shelter from temperature extremes. The relation of this type of manure management and its association with large fly populations cannot be overemphasized (Table 14).

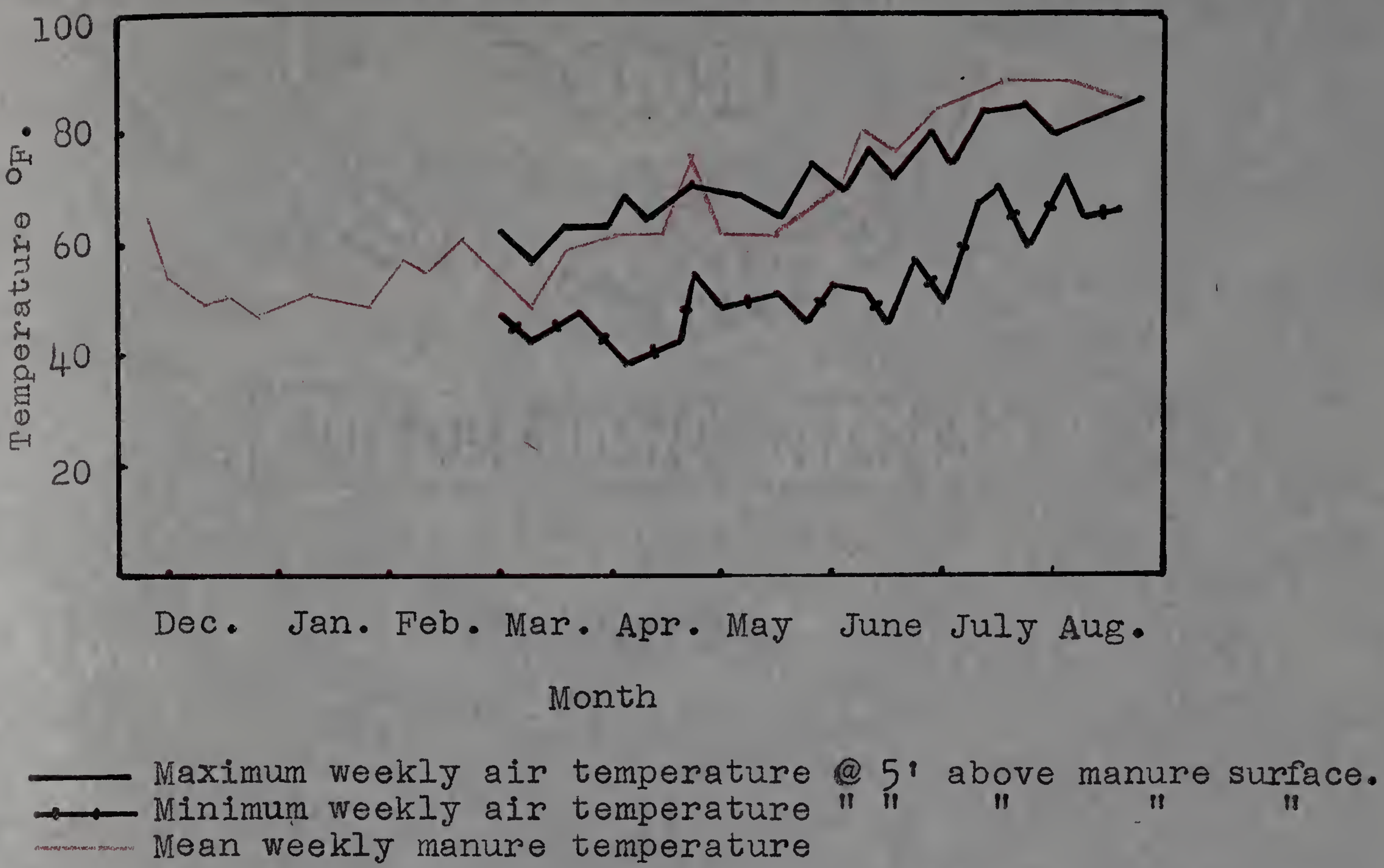
The temperature fluctuation in air and manure in the pits was determined in a poultry house. The pits in this house were cleaned in September. The depth of the manure increased gradually and reached a depth of six inches by early April. Temperature was measured by inserting a pocket thermometer into the manure at weekly intervals from November 1957 to March 1958. In February 1958, recording thermographs with extension elements were installed. One element was placed 3 inches deep into the manure in a pit while another was placed approximately 5 feet above the surface of the manure.

It was evident that the temperature of the manure in the pits remained fairly constant, although the air temperature at 5 feet above the surface of the manure fluctuated as much as 20°F. over a 24 hour period (Fig.14). The minimum air temperature reached in the upper level of the pen was 38°F. while the minimum manure temperature was only 48°F. (Fig. 13). Larvae are capable of slow development at low temperatures (p. 43). Also, it was noted that the manure temperature was more closely related to the maximum than to the minimum air temperature (Fig. 13). During late June, July, and early August 1958, the average manure temperature exceeded the maximum air temperature.

<u>Distribution of larvae in dropping pits</u>: It had been difficult at times to locate larvae in dropping pits although suspected of being there.

A study to determine the distribution of larvae in a pit was made in the winter of 1958. Four inch squares were scratched on the surface of the manure and the number of larvae in the mass of manure subtending the 4 inch square was noted.

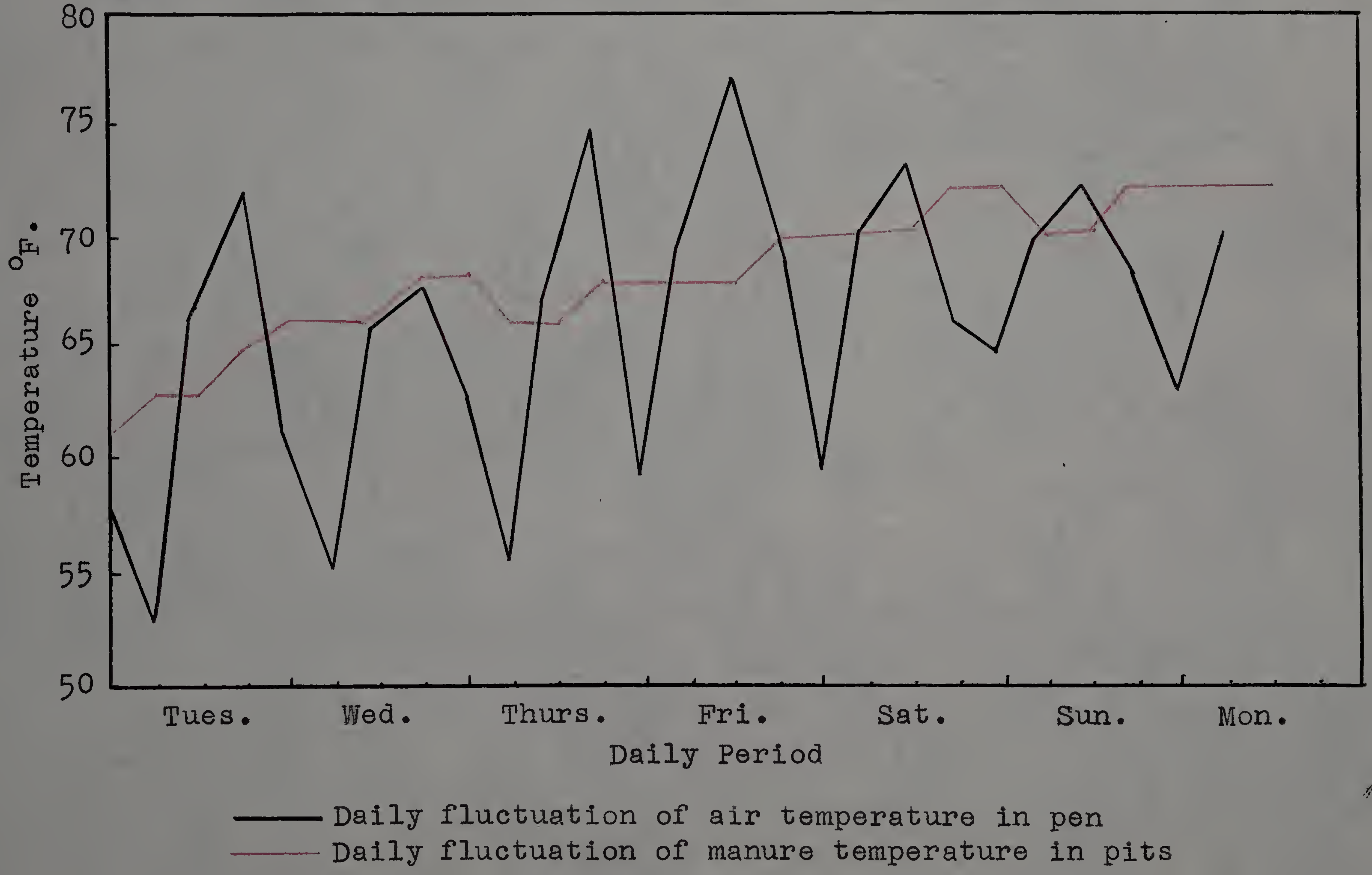
Fig. 13 -The relation of manure temperature in dropping pits to air temperature in pens - 1957-1958.




Ten separate examinations along the periphery and the middle of the pit were made (Fig. 15). The manure in the pit was approximately six inches in depth.

No larvae were detected in the central area of the pit, although they abounded at the periphery, particularly where vertical construction members provided 90° angles in the pit. This might well be an explanation for not detecting existing larvae on previous occasions.

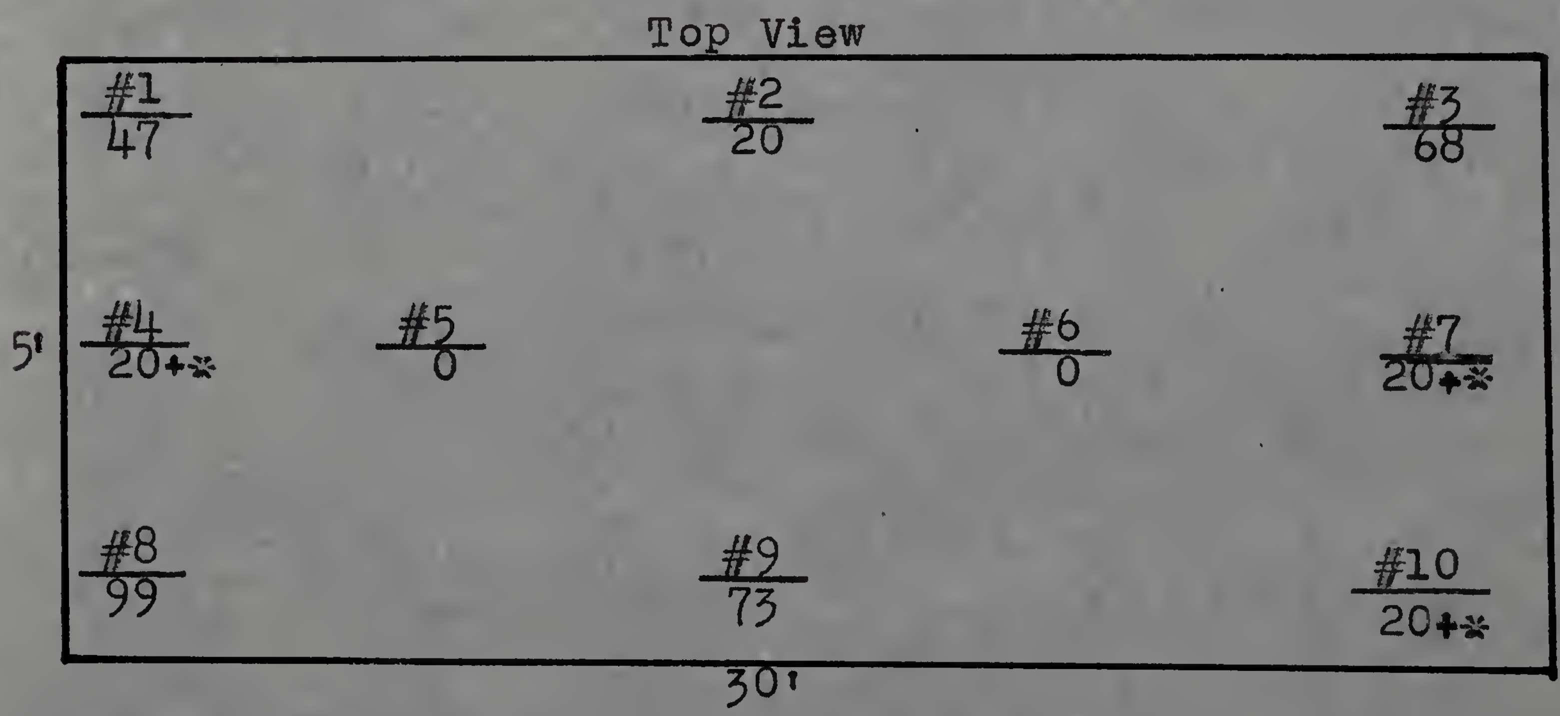
Fig. 14 -A comparison of air and pit temperatures in a poultry house April 14-22, 1958



Two factors which might explain this distribution are: (a) the apparent preference of the gravid female for ovipositing eggs on vertical surfaces adjoining the medium rather than directly upon the medium (Fig. 21), and (b) migration of the maturing larvae from wet to the drier portions of the medium, which occurred along the cracks of the supporting boards (Fig. 8).

The vertical distribution was determined in two inch layers in positions 1, 3, 5, 6, 8 and 9 (Fig. 15). The number of larvae occurring in these strata were recorded in Table 16.

Fig. 15 -The lateral distribution of third instar larvae of F. canicularis in a poultry dropping pit on Feb.4,1958.




* Estimate of numbers

TABLE 16

VERTICAL DISTRIBUTION OF *F. canicularis* THIRD INSTAR LARVAE IN A POULTRY DROPPING PIT, FEB. 4, 1958

| Depth In Inches | Manure Temp. °F. | Locality No. 1 | 3 | 5 | 6 | 8 | 9 | Total | Percentage Total |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1-2 | 55 | 8 | 12 | 0 | 0 | 14 | 17 | 51 | 17.8 |
| 2-4 | 58 | 26 | 32 | 0 | 0 | 47 | 25 | 140 | 48.9 |
| 4-6 | 56 | 13 | 24 | 0 | 0 | 38 | 21 | 96 | 33.3 |
| Totals | | 47 | 68 | 0 | 0 | 99 | 73 | 287 | |

No larvae were encountered on the surface of the medium and only a few immediately beneath it. Only 17.8% of the larvae were in the first two inch layer, while 48.9% were collected two to four inches beneath the surface. The position of these larvae was probably a direct effect of temperature variation at the different levels. Most of the larvae were approximately two to three inches from the bottom of the pits where the manure temperature was at a maximum. These larvae were active throughout the cooler months, from October to early May, while during the warmer months, mid-May to early September, the larvae may be on the surface of the manure.

The explanation for the occurrence of larvae on the surface of the manure during the warm spring months might be that the air temperature in the pens had reached a level which they preferred. Also, in the hot summer months, the manure in the pits dried considerably and the larvae migrate to the surface where they can maintain themselves in the recently-voided, moist droppings.

The pit temperature, from late June to late August, exceeded the maximum air temperature (Fig. 12). The manure temperature attained a maximum of 88°F. in the second and fourth weeks of July. Thus, this larval ascent to the surface might be the result of the larvae seeking escape from unfavorable to more favorable developmental environments.

The following observation in the laboratory supports the above interpretation. When newly hatched larvae, were placed in C.S.M.A. medium at 90°F., they soon succumbed.

Temperature preference of adults: This fly has been considered as a "cool weather fly", as evidenced by its poleward geographical distribution. Even on a smaller scale, involving only the premises of a poultry farm, a preference for cool environments was apparent.

This habit was demonstrated at several sites on a poultry farm, where temperature differences were measured (Tables 17, 18 & 19). With the exception of the first area listed in Table 17, the number of flies resting per ten linear feet of ceiling joists was used as an index.

TABLE 17

TEMPERATURE PREFERENCE OF RESTING ADULTS OF F. canicularis IN A POULTRY BUILDING ON JULY 1, 1958

| Area | Temp. °F. | No. Resting Flies | Comments |
| --- | --- | --- | --- |
| Siding exposed to sun | 98 | 0 | Flies absent on south wall |
| Ante-Hallway | 88 | 10 | Flies more abundant here earlier in year when cool |
| Pen | 86 | 42 | Counts made over dropping pits |
| Hallway | 82 | 106 | Usually very abundant |
| Store Room | 82 | 140 | " " " |
| Stable | 78 | 230 | Cool here, flies very abundant and actively circling. |

Counts obtained in the pen were made over the dropping pits. Fewer adults were resting away from the pits, suggesting that the counts obtained in the pen would have been considerably lower, were it not for the attraction of the hen manure as an oviposition site.

Similarly, it is suspected that the few flies found in the outer hallway were "overflow" from the cooler, adjoining inner hallway which harbored considerable numbers.

The preference of this species for cooler areas was noticeable on these premises, since fewer adults were in areas where temperatures exceeded 82°F., but many were at the cooler areas approximating 78°F.. Also while in the field, it was observed that the sides of poultry buildings having a southerly exposure were occupied by flies on cool or overcast days but that flies were absent from these surfaces on hot, sunny days (Table 18 & Fig. 16).

Temperature records and fly counts were made weekly and taken from a siding shingle fully exposed to the sun's rays and one shielded from the sun's rays. These shingles were approximately 2 feet apart. The results are indicated in Table 18. Three times as many resting adults were observed on the shingle which was shielded from the direct summer sun's rays as compared with the number of adults found resting on the shingle exposed directly to the sun's rays. The average temperature of the shaded shingle was 78.6°F. as compared with an average temperature of 84.4°F. exhibited by the shingle which was not shaded.

During the hot summer days in July when the air temperature exceeded 84°., flies did not rest on sides of buildings exposed to the sun, but were found on the shaded sides. However, if the next day was overcast and air temperatures dropped below 80°F., flies abounded on all the walls of these buildings.

TABLE 18

NUMBER OF RESTING ADULTS FOUND PER SQ. FT. SHINGLE EXPOSED TO THE SUN COMPARED TO ONE SHIELDED FROM THE SUN 1958

| Date | Sun | | Shade | |
|---|---|---|---|---|
| | Temp. °F. | No. Adults | Temp. °F. | No. Adults |
| May 27 | 88 | 2 | 72 | 21 |
| June 3 | 78 | 2 | 70 | 9 |
| June 10 | 60* | 10 | 60 | 8 |
| June 24 | 84 | 0 | 78 | 4 |
| July 1 | 98 | 0 | 90 | 0 |
| " 8 | 86* | 0 | 86 | 0 |
| " 15 | 88* | 0 | 88 | 0 |
| " 22 | 74* | 7 | 74 | 9 |
| " 29 | 90 | 0 | 87 | 0 |
| Aug. 12 | 88 | 0 | 78 | 4 |
| " 19 | 95 | 0 | 82 | 2 |
| Totals | Avg. 84.4 | 21 | Avg. 78.6 | 57 |

* Overcast

To further test the cooler temperature preferences of this fly, fly ribbons were placed in the midst of "play flights" occurring in the various protions of the premises previously described (Table 19).

TABLE 19

TEMPERATURE PREFERENCE OF CIRCLING ADULTS ON JULY 15, 1958, UTILIZING THE NUMBER OF FLIES CAPTURED ON RIBBONS IN PLACE FOR ONE HALF HOUR AS INDICES

| Area | Temp. °F. | No. Flies | Percentage Of Total |
|---|---|---|---|
| Cellar | 76 | 470 | 23.6 |
| Stable | 78 | 427 | 21.4 |
| Store Room | 78 | 552 | 27.7 |
| Hallway | 80 | 430 | 21.6 |
| Pen | 84 | 109 | 5.4 |

Again, the cooler areas harbored more active adults with a decrease in the numbers present where temperatures were 84°F.

On several visitations to poultry farms, it was noticed that the adults commonly congregated on the upper areas of wall surfaces and on the ceilings. On one occasion, the vertical distribution of the resting adults in a pen was observed closely, using six linear feet of six inch boards, of which the walls were constructed, as indices (Table 20). The ceiling temperature was 73°F., indicating that this was probably a temperature response.

TABLE 20

VERTICAL DISTRIBUTION OF RESTING ADULTS ON WALL OF PEN JUNE 24, 1958, USING HORIZONTAL BOARDS, 6'x6" AS INDICES

| Board No. | Height (In.) | Number Of Flies | Percentage Of Total |
|---|---|---|---|
| Ceiling * | 60 | 72 | 50.34 |
| 10 | 54-60 | 26 | 18.18 |
| 9 | 48-54 | 24 | 16.78 |
| 8 | 42-48 | 7 | 4.89 |
| 7 | 36-42 | 5 | 3.49 |
| 6 | 30-36 | 1 | 0.69 |
| 5 | 24-30 | 1 | 0.69 |
| 4 | 18-24 | 3 | 2.09 |
| 3 | 12-18 | 1 | 0.69 |
| 2 | 6-12 | 0 | 0.00 |
| 1 | 0-6 | 3 | 2.09 |
| 10 (Total) | | 143 (Total) | |

* 2 inch strip of ceiling adjacent to wall

The ceiling was occupied by many flies. The number of flies decreased progressively per board below the ceiling.

Fig. 16 -During the cooler days and months, adults of the little house fly abound on the outsides of poultry houses. When temperatures rise to 85°F., adults retreat to cooler, shaded hallways such as the one shown above and only a few are found resting on sides of buildings exposed to the sun. (Original)

Seasonal distribution: A few adults were in the poultry houses during the winter months. The activity of these adults became noticeable in late February when air temperatures in the pen approximated 54°F. Early spring emergence from pupae and crevices was determined by personal observations and by fly ribbon collections. Mailing tubes containing ribbons and instructions for exposure on March 1 and return by mail, were given to poultrymen in advance. The ribbons were to be returned when half covered with flies. On four farms this emergence occurred before March 10, while on the majority of farms, this occurred before March 20 (Table 21).

TABLE 21

APPEARANCE OF _F. canicularis_ ADULTS IN EARLY SPRING AT POULTRY FARMS DURING 1957 -1958

| Farm No. | Locality | Date | Method Employed For Determination |
|---|---|---|---|
| 13 | Lynnfield Ctr., Mass. | March 4,'58 | Personal observation |
| 18 | So. Amherst, Mass. | March 7,'58 | " " |
| 23 | Newton Jct., N.H. | March 7,'57 | " " ** |
| 31 | Southwick, Mass. | March 10,'53 | Mailed Ribbons * |
| 21 | Amherst, Mass. | March 16,'57 | " " |
| 13 | Lynnfield Ctr., Mass. | March 18,'57 | Personal observation |
| 19 | So. Amherst, Mass. | March 18,'57 | " " ** |
| 14 | Essex, Mass. | March 20,'57 | " " |
| 5 | W.Bridgewater, Mass. | April 1,'58 | Mailed Ribbons * |
| 22 | Amherst, Mass. | April 8,'57 | Personal observation |
| 16 | Lenox, Mass. | May 7,'58 | Mailed Ribbons * |

* Ribbons placed by farmers
** Actual emergence observed

In 1958 crocuses which were planted in front of a house having a southerly exposure appeared about March 1. first showed color on March 10, and were in full bloom by March 15. In 1959, crocuses and snowdrops were in full bloom on March 24, while buds on red maple were greatly swollen and pussy willows appeared. This was the only phenological data obtained which coincided

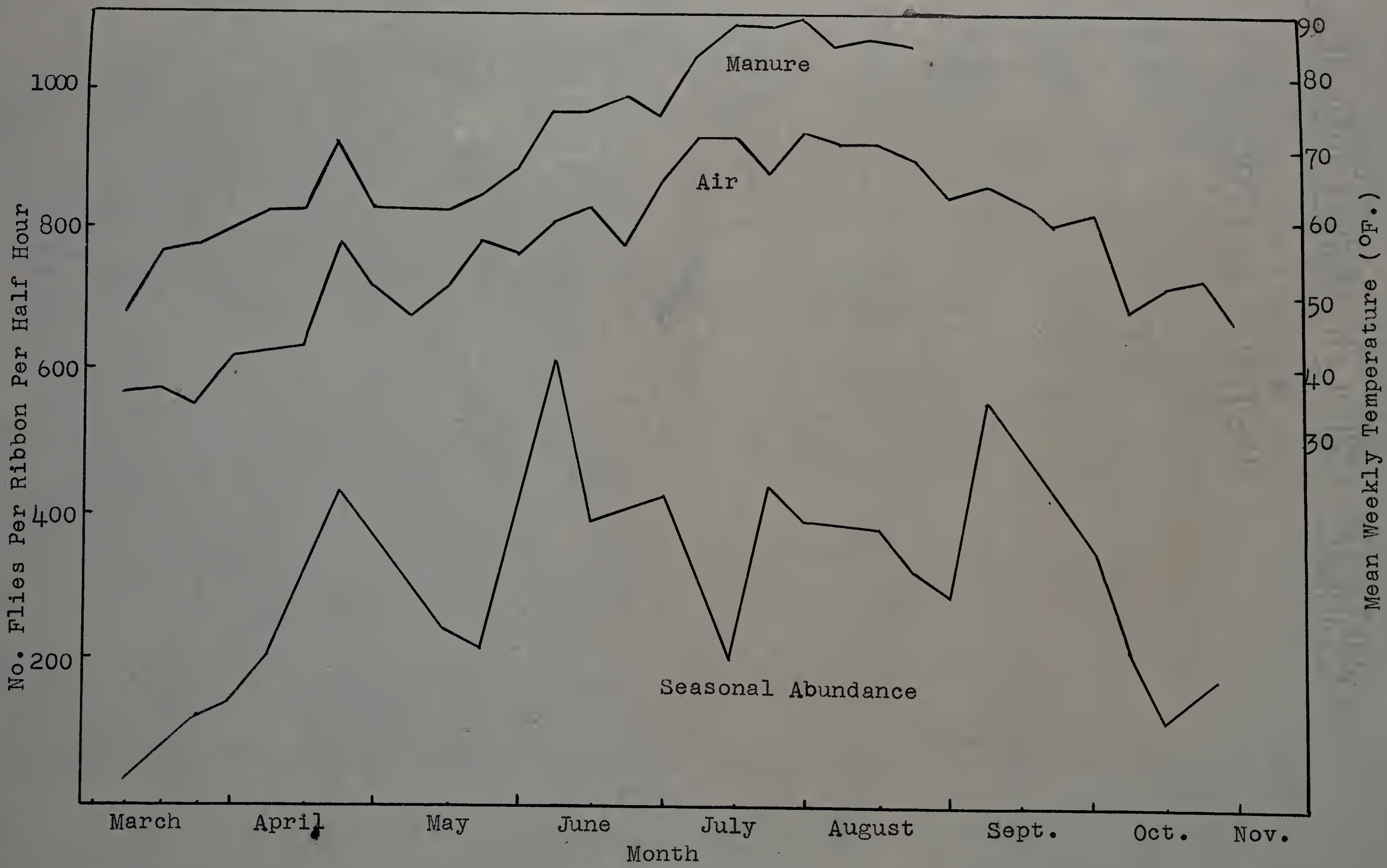



Fig. 17 -Seasonal distribution of adults of _F. canicularis_ on a poultry farm during 1958 utilizing the number of flies caught on fly ribbons exposed for half hour periods as indices.

with adult emergence.

Fly ribbons served as a useful means of measuring seasonal fluctuations in numbers of this species (Fig. 19).

Fig. 18 -Adults of F. canicularis resting on a light bulb. The circling flights of these flies are usually beneath objects suspended from the ceiling. (Original)

During 1958 the adult population increased steadily during March and early April, and reached its first peak during the third week in April (Fig. 17). A noticeable decline followed this first peak and continued until the second week in June when the second peak occurred. This second peak was followed by a third peak in the third week in July. A fourth peak occurred in early September and a fifth in the first week of November.

Fig. 19 -Taking advantage of the fact that adults circle objects suspended from the ceiling, a timed exposure of fly ribbons serves as a convenient and efficient method of obtaining population densities. (Original)

The population density was greatest during early June and September. During these periods, the adult "play flights" contained such large numbers as to disturb persons walking through the areas where they congregated. On cool days during the April and September peaks, walls of buildings were virtually covered with these flies.

The adults were distinctly noticeable throughout the April and October peaks, since these flies constitute the major fly population at this time. In late December of 1957, adults were still active. The only period in which flies were not captured on ribbons was from January 3, 1957 to February 7, 1958, an interval of approximately one month.

There was an indication of a correlation between temperature and fly abundance (Fig. 17). The maximum numbers of flies were captured when the mean weekly air and manure temperature approximated 60-65°F. and 70-80°F. respectively and that mean weekly temperatures above or below these ranges tended to reduce the population. Additional seasonal data is necessary to substantiate these indications.

Invasion of homes: This study resulted from an increasing number of complaints of annoyance caused by the invasion of flies into homes, particularly those near poultry farms.

To determine the extent to which this fly invaded homes, the cooperation of a local complainant was solicited. This homeowner was frustrated with his attempts to control the multitudes of flies which plagued his home and was eager to cooperate.

This residence was old and in close proximity to a heavily infested poultry farm. The windows were neither tightly constructed nor adequately screened. The only plantings about the house were two ornamental bushes (Taxus spp.) on either side of the front entrance. A large maple tree, approximately 25 feet south-west of the house, shaded the house only during the late daylight hours. Sanitation on the premises was considered good. The kitchen screen door was opened frequently, due to the activities of two children of this family. The inadequate screening and frequent opening of screen doors probably afforded points of entry for the flies.

A fly ribbon was hung in place directly over the kitchen table in this residence. Each week the ribbon, with the captured flies was removed and replaced. The visitations to this home were as regular as circumstances permitted, resulting in an adequate representation of the seasonal fluctuations in numbers on the premises (Fig. 20).

In the second week of August 1957, a maximum of 418 flies was collected on the ribbons. Another major peak occurred during the first week in June of 1958. Other peak periods occurred during mid-October 1957, early January of 1958 and late April of 1958. Flies were present in other rooms as well as in the kitchen, but not in as great abundance. Flies were collected in this

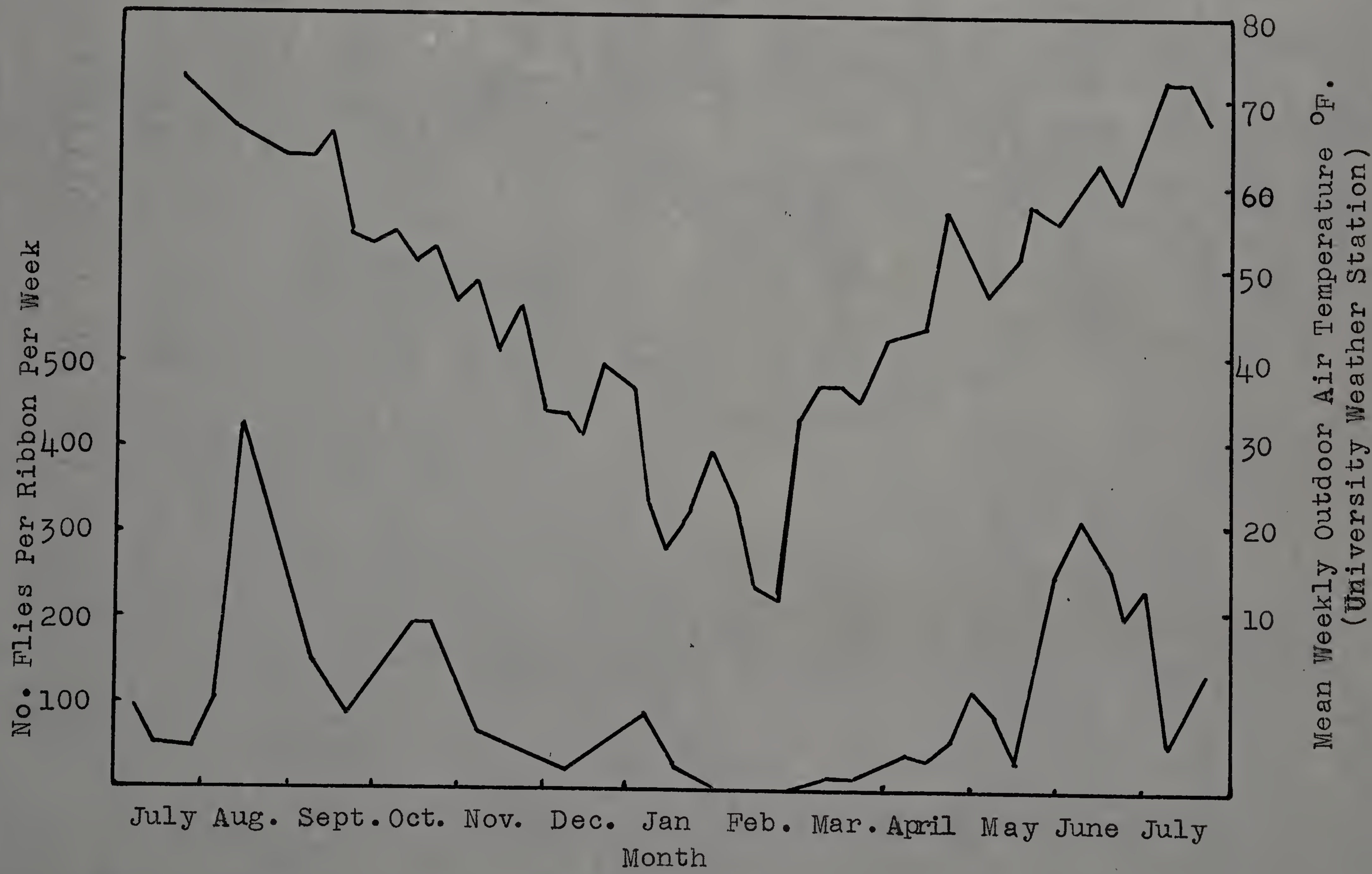



Fig. 20 —Number of adults captured per ribbon when exposed for weekly periods over the kitchen table in a house located approximately 100 yds. from a poultry farm experiencing a heavy infestation of F. *canicularis*, 1957-1958.

kitchen throughout the year, except for a period of approximately three weeks during February of 1958.

An attempt to correlate the number of captured flies with temperature appears in Fig. 20. The peaks occured during the periods when the mean weekly air temperatures approximate 55°-65°F. Since the size of the adult population in an area is probably the major factor affecting the number of adults found in homes, a more direct correlation is evident when the number of flies found in homes (Fig. 20), is compared with seasonal abundance (Fig. 17), during 1958. Flies were detected on both premises during the first week of March 1958. Also, population peaks occurred at approximately the same time.

Upon questioning the occupants, it was learned that the flies did not settle readily on exposed human foods. However, they also commented that *M. domestica* was particularly obnoxious in this respect. There was no reason to believe that adults enter homes for hibernation purposes. The movement of flies from outdoors to indoors to avoid heat and cold is a more tenable explanation.

*Infestations at four animal housing units*: Upon visual inspection of various animal housing units, a difference in the apparent degree of infestation was noticeable. This observation was checked with ribbon collections (Table 22). All observations were made approximately at the same time of day.

TABLE 22

THE NUMBER OF ADULTS OF <u>F. canicularis</u> COLLECTED AT FOUR INDOOR SITES IN 1958 ON RIBBONS EXPOSED FOR HALF HOUR PERIODS

| Date | Poultry Farm #18 | University Farms | | |
|---|---|---|---|---|
| | | Hog | Dairy | Poultry |
| April 5 | 70 | 6 | - | - |
| " 11 | 260 | 9 | 37 | - |
| " 18 | 424 | 20 | - | - |
| " 23 | 390 | 16 | - | - |
| June 4 | 615 | 2 | 12 | 97 |
| " 24 | 428 | 3 | 16 | 115 |
| July 1 | 146 | - | - | 6 * |
| " 8 | 187 | 2 | 6 | 19 * |
| " 28 | 284 | 4 | 7 | 13 * |
| Totals | 2804 | 62 | 78 | 250 |
| Avg. No. Flies Per Ribbon | 311.6 | 7.8 | 15.6 | 50.0 |

* Insecticide treated cords placed in pens

The number of flies captured on both poultry farms was much greater than in either the hog or dairy barns. The incidence of this fly at the University sheep barn was not detected, although it was in close proximity to the hog barn.

Although manure handling practices at the University hog farm were such that they afforded ample opportunity for fly breeding, the little house fly was never present in large numbers.

At the hog farm electric fly panels were used at three windows as a means of fly control, and electrocuted flies piled up on the sills. A sample of these flies was collected and identified (Table 23). Fannia constituted only a small proportion of the total fly population at the hog farm.

TABLE 23

RELATIVE ABUNDANCE OF Fannia spp. AT THE UNIVERSITY HOG FARM JUNE 24, 1958

| Fly Specimens | No. Collected | Percentage Of Total |
|---|---|---|
| Musca domestica | 93 | 62 |
| Calliphoridae | 31 | 21 |
| Stomoxys calcitrans | 15 | 10 |
| Fannia canicularis | 3 | 2 |
| Others | 8 | 5 |

Composition of "play flight" populations: From June to September 1958, fly ribbons were examined to determine the sexual composition of the captured flies (Table 24).

TABLE 24

SEXUAL COMPOSITION OF ADULT CIRCLING POPULATIONS OF *F. canicularis* AT THE UNIVERSITY POULTRY PLANT, 1958

| Date | No. of Adults Captured | No. of Females | No. of Males | Percentage Males |
|---|---|---|---|---|
| June 14 | 240 | 50 | 190 | 79.1 |
| June 25 | 810 | 213 | 597 | 73.7 |
| July 9 | 400 | 126 | 274 | 68.5 |
| July 16 | 244 | 112 | 132 | 54.0 |
| July 23 | 138 | 57 | 81 | 58.6 |
| July 30 | 150 | 68 | 82 | 54.6 |
| Aug. 6 | 226 | 97 | 129 | 57.0 |
| Aug. 19 | 182 | 84 | 98 | 53.8 |
| Aug. 26 | 244 | 109 | 135 | 55.3 |
| Sept. 3 | 408 | 159 | 249 | 61.0 |
| Sept. 9 | 255 | 119 | 136 | 53.3 |

Oviposition habits: Unlike many of the other common domestic flies, which lay their eggs in clumps, the little house fly lays its eggs singly. This was noted both in the field and in the laboratory (Fig. 22).

Also, the eggs are frequently laid on vertical surfaces adjoining the oviposition medium particularly when this medium is wet. During the early spring months and in the late fall when the manure is wet and flies abound, the retaining boards of manure pits bear a multitude of eggs (Fig. 21). On one occasion, eggs were noted 15-20 inches above the surface of the breeding medium on a concrete pillar.

Fig. 21 -A view inside a manure pit, showing the large number of eggs oviposited on a vertical retaining board. The surface of the manure is the dark area in the lower foreground and the eggs are the white spots occurring intermittently across the center of the photo. (Original)

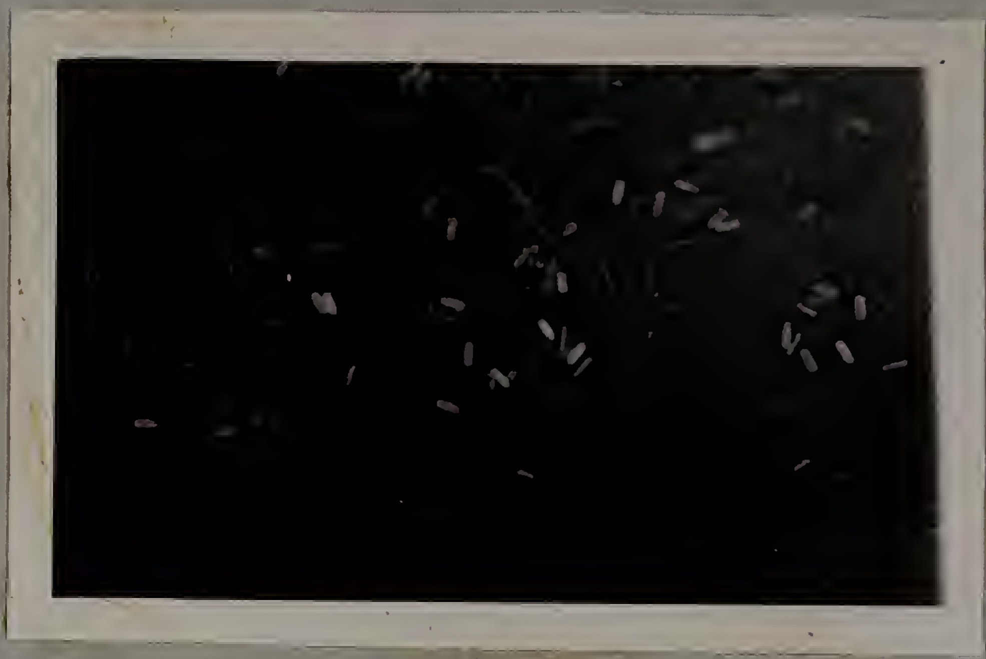


Fig. 22 -A closer view, earlier in the season, of the retaining board in Fig. 21 showing placement of the eggs singly by the female. (Original)

CONTROL

Predators: During the course of this study, six natural enemies of the little house fly were observed. Of these, four were predators.

The mite, *Macrocheles muscae domesticae* (Scopoli) was frequently seen scurrying over the surface of the manure in the pits. Adults of this mite often were firmly attached to flies by the insertion of their mouthparts through the ventral intersegmental membraneous areas. The identification of these specimens was first established by a department member, Mr. John A. Weidhaas, and later confirmed by Baker (1958).

As many as six mature mites have been observed attached on the venter of a single adult little house fly. Only a small portion of the total population was infested (Table 25). When chicken manure was brought into the laboratory, both nymphs and adults were observed feeding on eggs and first instar larvae of the little house fly. The mites apparently destroyed many more prey than were necessary for their sustenance. The prey was held firmly by the second pair of legs as the mouthparts were inserted. The first pair of legs waved in the air constantly in an antennae-like fashion. The prey was greatly disfigured at the termination of the attack which lasted approximately three minutes. The mites apparently avoid strong light, since they rapidly sought cover when strong light was suddenly directed on them.

This is the first record of preying by M. muscae domesticae on Fannia spp. Phoresy was the only role of such mites until Pereira and deCastro reported nymphs of M. muscae domesticae preying on the eggs of the common house fly (Baker and Wharton, 1952).

The common zebra spider, Salticus scenicus (Clerck) was observed to prey on the adults of the little house fly. This common jumping spider was found inhabiting outside walls of poultry buildings. The spider approached within one centimeter of its prey, remained motionless momentarily, then with a leap, quickly captured and paralyzed its prey. This was observed on three separate occasions.

The carpenter ant Camponotus pennsylvanicus (DeGeer) preyed on adults of the little house fly while the flies were ingesting honeydew on apple leaves. The ants stalked and seized the unwary flies and transparted them to their nests. This phenomenon was

TABLE 25

OCCURRENCE OF MITES ATTACHED TO ADULTS OF *F. canicularis* CAPTURED ON FLY RIBBONS AT THE UNIVERSITY POULTRY FARMS 1958

| Date | Flies Examined | Mite Bearing Adults | | Percentage Infested |
|---|---|---|---|---|
| | | No. Males | No. Females | |
| June 14 | 248 | 0 | 1 | 0.40 |
| " 18 | 176 | 1 | 0 | 0.56 |
| " 25 | 810 | 9 | 6 | 1.85 |
| July 6 | 169 | 0 | 2 | 1.80 |
| Sept. 10 | 1062 | 6 | 14 | 1.87 |

observed weekly from June 10 until July 8. After July 8, the aphid population diminished and honeydew deposits were no longer present to attract adults of *F. canicularis*.

During the early summer of 1958, the yellow dung fly, *Scatophaga stercoraria* (L.) was observed preying on *F. canicularis* adults on two occasions.

*Parasites:* In late August of 1958, large numbers of *F. canicularis* became infected with a fungus, suspected to be *Empusa muscae* (Cohn). Infected specimens were sent to Dr. E. A. Steinhaus (1958), insect pathologist, who confirmed the identification. In the laboratory, this fungus decimated cultures of the little house fly.

The Pteromalid, Pachycrepoideus vindemmiae (Rond.) (= dubius Ashmead), was reported by Girault and Sanders (1910) as parasitizing several species of Diptera, but Fannia spp. were not among those listed. Thompson (1943, 1951) and Peck (1951), do not mention Fannia spp. as hosts of this Pteromalid.

P. vindemmiae appeared in laboratory cultures of F. canicularis pupae in November and parasitization of 70 % in exposed cultures had resulted by early spring (Fig. 23). This parasite was also found in pupae of F. scalaris. Crandell (1939) published an excellent biological and morphological account of this species. This parasite was identified by B. D. Burks (1958), U. S. N. M..

Fig. 23 -A parasitized pupa of F. canicularis showing the exit hole of the adult Pteromalid Pachycrepoideus vindemmiae (Rond.). Note also, the V. shaped anus and the median folds of the ventral abdominal sclerites, pupal characters which aid in distinguishing the little house fly from F. scalaris.

<u>Insecticide treated cord</u>: During the early summer of 1958, parathion (13.7%) - Diazinon (3.5%) treated cords were installed in pens on a local poultry farm to combat fly population increases. Effectiveness was measured by use of fly ribbons hung in place for half hour periods in the same pen and in a grain room (Table 26).

TABLE 26

EFFECT OF TREATED CORDS ON POPULATIONS OF *F. canicularis* UTILIZING RIBBONS HUNG IN PLACE FOR ONE HALF HOUR PERIODS AS INDICES

| Date | Pen | | Grain Room | |
|---|---|---|---|---|
| | No. Flies | Percentage Reduction | No. Flies | Percentage Reduction |
| June 20 * | 87 | --- | 106 | --- |
| June 24 * | 94 | --- | 84 | --- |
| June 26 | 17 | 81.9 | 12 | 85.7 |
| July 1 | 26 | 72.3 | 32 | 61.9 |
| July 8 | 15 | 84.0 | 8 | 90.4 |
| July 15 | 15 | 84.0 | 31 | 63.0 |
| July 28 | 13 | 86.1 | 9 | 89.2 |

* Before cord installation

An immediate reduction of 80-85% in the adult fly population was noticeable as evidenced by the above figures. This level of control appeared to exist for at least a month after initial installation at which time counts were discontinued.

## SUMMARY

*F. canicularis* adults were collected in the field by suction with the aid of a flexible hose connected to an electric fan. The captured adults were placed into newly developed, aluminum holding cages and returned to the laboratory. Eggs from these adults were placed in a modified C.S.M.A. cereal medium.

At an air temperature of 80°F., the approximate developmental periods for the immature stages in this medium were as follows: egg: 1 1/2-2 days; larvae: 8-10 days; pupa: 9-10 days. The pre-oviposition period was 4-5 days. Thus, a total of 23-25 days was required for development from egg to egg. When newly hatched larvae were kept at 48°F., adults emerged approximately 5 months later. The larvae did not develop at 90°F.

The average length of the immature stages was as follows: egg: 0.88 mm.; first instar; 1.0 mm.; second instar: 2.8 mm.; third instar: 7.0 mm. and pupa: 5.2 mm. Drawings illustrating the morphological development of the cephalo-pharyngeal skeleton in the three instars were made. Also, differences have been found and described for easy recognition of the larvae, pupae and

adults of _F. canicularis_ and _F. scalaris_, a species which closely resembles the little house fly. It is frequently encountered in similar environments and can easily be confused with the little house fly.

The sex ratio of adults emerging from pupae was approximately 0.5. Females had a longer life span than males. 50% of the male population died within 14 days after emergence, with a few remaining alive up to 28 days, while 50% of the female population died within 24 days, with a few remaining alive up to 54 days. During the continuous rearing in the laboratory, no evidence of diapause appeared.

As many as 231 eggs were laid by a single female during her life span. The eggs were laid singly and frequently on vertical surfaces above the breeding source, particularly when the medium was wet. Hen manure was the most attractive oviposition medium when compared with hog, cow, sheep and horse manures.

The larvae displayed negative phototropism while adults displayed a positive phototropism. Adults were unable to fly against winds exceeding 16 m. p. h.. Adults preferred temperatures under 83°F..

Observations at local poultry farms in conjunction with poultry farm inspection in Massachusetts, Rhode Island, Vermont and New Hampshire in 1957 - 1958 provided valuable data concerning the biology of this species under field conditions.

Overwintering stages were mature larvae, pupae and adults. No eggs or young larvae were found at the localities examined. Larvae and pupae were in manure pits. Adults were inactive and hibernated in crevices, becoming active on unusually warm days.

During late February, 1958, the hibernating adults became noticeably active. In early March, this small population increased steadily due to the emergence of adults from overwintering pupae. This appreciable increase in the population continued until the first peak in the seasonal distribution which occurred during late April. The maximum peak in abundance occurred in mid-June, followed by another major peak in early September. Adults were less abundant throughout this interim. Appreciable activity continued until late October, after which sluggish adults were observed sporadically. Oviposition continued until November 9, in 1957.

Since the adults characteristically engaged in sustained, circular flight activity beneath suspended objects in cool, shaded areas, timed exposures of fly ribbons in the midst of such activites proved an efficient method of obtaining the seasonal abundance records mentioned above. The majority of these circling populations consisted mainly of males. It was also noted that adults traveled little or none at all after alighting on a surface.

Adults invaded one home in greatest numbers during late August of 1957 and early June of 1958. The incidence of flies in the home in 1958 was closely correlated with populations existing at breeding sources on a nearby poultry farm. Except for the month of February adults were active in this home throughout the year. In spite of the many flies in this home, they seldom alighted upon persons or exposed food in the room.

Data collected in a poultry house showed that although the daily air temperature in a pen may fluctuate as much as 20°F. in a 24 hour period, the manure temperature in pits remained fairly constant. The maximum and minimum mean weekly temperature attained in this pen from March to August 1957 were as follows: manure temperature in pits 88°F., 38°F. and air temperature of pens 84°F., 38°F.. The mean weekly manure temperature was more closely related to the maximum weekly air temperatures than to minimum weekly air temperatures.

Other quantitative data obtained primarily from a winter survey of poultry farms indicated: (a) that poultrymen employing the pit system of manure management usually had high populations of this fly, (b) that poultrymen employing the open floor management or the dropping board system had low or undetectable populations, (c) that poultrymen who employed the pit system, but frequently cleaned them, had lighter infestations, (d) that both Fannia spp. were the only larvae encountered during these winter visitations, (e) that farmers plagued by large numbers of these flies were unaware as to the breeding sources within their buildings, (f) that the little house fly was readily encountered in all of the states visited.

Six natural enemies of F. canicularis and one of F. scalaris have been observed. The four predators of the little house fly included; the zebra spider, Salticus scenicus (Clerck), the carpenter ant Camponotus pennsylvanicus (DeGeer), the Gamasid mite, Macrocheles muscae domesticae (Scopoli), and the yellow dung fly Scatophaga stercoraria (L.). The two parasites include the entomopthorous fungus, Empusa muscae (Cohn) and the Pteromalid, Pachycrepoideus vindemmiae (Rond.) (= dubius Ashmead). These observations serve to establish the following new host records:

the mite M. muscae domesticae on F. canicularis and the wasp P. vindemmiae on F. canicularis and F. scalaris.

Cotton cords impregnated with Diazinon and parathion reduced a population of the little house fly rapidly.

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